

MINISTRY OF FUEL AND POWER

EXPLOSION AT EASINGTON COLLIERY COUNTY DURHAM

Report

On the causes of, and circumstances
attending, the explosion which occurred at
Easington Colliery, County Durham,
on the 29th May, 1951.

BY

H. C. W.

H.M. Chief Inspector of Mines

*Presented by the Minister of Fuel and Power to Parliament
by Command of Her Majesty
September, 1952*

LONDON

HER MAJESTY'S STATIONERY OFFICE

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at back*

Report on the causes of, and circumstances attending, the explosion which occurred at Easington Colliery, County Durham, on the 29th May, 1951

*The Right Honourable Geoffrey
Minister of Fuel and Power.*

31st July, 1952.

SIR,

I.—INTRODUCTORY

In accordance with the direction of your predecessor, the Right Honourable Philip Noel-Baker, M.P., I held a formal Investigation under the provisions of Section 83 of the Coal Mines Act, 1911, into the causes and circumstances of the Explosion which occurred at Easington Colliery, County Durham, on 29th May, 1951.

I now have the honour to submit the following Report, which shows that firedamp was ignited when the picks of a coal cutting machine operating on a retreating longwall face struck pyrites. The explosion spread through 16,000 yards of roadway and caused the deaths of 81 persons. Two persons died in the ensuing rescue operations.

The Inquiry was opened at the Easington Colliery Welfare Hall, Easington, on 30th October and terminated on 15th November. Evidence was taken on 13 days and 75 witnesses were examined. A list of these witnesses is given in Appendix II.

The appearances were as follows :—

For Ministry of Fuel and Power

Mr. T. A. Jones, O.B.E., H.M. Divisional Inspector of Mines.

Mr. J. Cowan, H.M. Principal Electrical Inspector of Mines.

Mr. A. H. A. Wynn, Director of the Safety in Mines Research Establishment.

For National Coal Board

Mr. W. L. Miron, O.B.E., T.D., Secretary, East Midlands Division.

Mr. W. F. Richardson, Chief Safety Engineer, Headquarters.

For National Union of Mineworkers

Mr. S. Watson, C.B.E., General Secretary, Durham Area.

Mr. R. W. Williams, M.P.

Mr. C. Robinson, Chairman, Easington Miners' Lodge.

For National Association of Colliery Overmen, Deputies and Shotfirers

Mr. B. Walsh, J.P., President.

Mr. J. Crawford, General Secretary, Durham Area.

For British Association of Colliery Management

Mr. R. W. Anderson, M.C.

For National Association of Colliery Managers

Mr. Robert Williams.

Professor I. C. F. Statham.

For Association of Mining Electrical and Mechanical Engineers

Mr. H. Brocklesby, Vice President.

For Federation of Small Mines of Great Britain

Mr. T. S. Nicholson, Chairman

Mr. E. C. Kennedy, Secretary

} Durham Association of Small Mines.

For Northern Colliery Officials and Staffs' Association

Mr. C. Whiteley.

For Durham Colliery Mechanics' Association

Mr. T. Murray.

II.—GENERAL

Easington Colliery is situated on the coast in the County of Durham, between the ports of Seaham Harbour and West Hartlepool, nine miles north-west of the latter. There are two principal shafts, both circular and both 20 feet in diameter. The North Shaft, the downcast, was sunk to the Hutton Seam at a depth of 1,430 feet, the present winding level being at the Main Coal Inset at a depth of 1,130 feet. The South Shaft, the upcast, is 1,500 feet deep to the Hutton Seam. Both are used for winding men, mineral and materials. A third shaft, the West, 470 feet deep, is connected to the South Shaft by a drift at the 164 feet level. Although sinking was started in 1899, coal drawing did not begin until 1910 because of difficulties encountered in passing through water-bearing strata.

Management

The mine was one of eight forming the No. 3 Area of the Durham Division of the National Coal Board. The principal officials were :—

Area General Manager	.. ..	Mr. F. W. Fry
Area Production Manager	.. ..	Mr. J. P. Hall
Group Agent .. ..	.. ..	Mr. T. N. Sneddon
Assistant Agent .. ..	.. ..	Mr. H. E. Morgan
Manager .. ..	.. ..	Mr. T. Hopkins
Undermanager—North Pit	.. ..	Mr. H. E. Emery
Undermanager—South Pit	.. ..	Mr. A. Carr

Output and Persons Employed

At the time of the disaster 2,235 persons were employed underground and 652 on the surface. The average daily output was 3,600 tons.

As is common in Durham mines, there were three production shifts, the fore-shift, which lasted from 3.30 a.m. to 11.07 a.m., the back-shift, from 9.45 a.m. to 5.22 p.m., In addition to these main shifts a repair shift known as the stone-shift, consisting mainly of stone workers and coal cutter operators, descended at 10.0 p.m. and ascended at 5.37 a.m.

Seams Worked and Method of Working

The workable seams, in descending order, are the Five Quarter, Seven Quarter, Main Coal, Low Main and Hutton. Before the explosion there were 14 producing districts in the North Pit, of which five were in the Five Quarter, two in the Seven Quarter and seven in the Low Main Seam.

Bord and pillar was the usual method of working, the pillars being formed by arcwall heading and extracted by lifts worked with the aid of either pneumatic picks or arcwall machines. Longwall, both advancing and retreating, was also practised.

The Duckbill District

The explosion occurred in the Five Quarter Seam, in the New or West District, more popularly known as the Duckbill District, the name that I shall use throughout this Report. It lies to the north-west of the shafts and north of an area reserved for the protection of the colliery village.

At the shaft the Five Quarter Seam, including three bands of stone totalling 13 inches, is six feet two inches thick, the roof is of shale seven feet thick, with laminated sandstone and sandy shale above, and the floor is of clay one foot two inches thick, followed by about seven feet of alternate bands of coal and clay. In the Duckbill District the seam is about six feet ten inches thick, the shale is thicker than at the shaft and the floor is fairly hard. The seam is some 1,050 feet deep and it dips at 1 in 32 to the north-east. A sample of the coal taken near to the entrance of the district gave a volatile content of 34.9 per cent. on a dry ash free basis.

From the downcast shaft, as shown in Plan No. 1, the main haulage road and intake airway extends in the Main Coal Seam for 380 yards to the north and then for 640 yards along a road known as the West Level. At this point a stone drift rises at one in six to the north and, passing through the Seven Quarter Seam, enters the Five Quarter Seam. The return airway follows a similar, though more circuitous course, including two short drifts at an inclination of one in two, to the Five Quarter Seam. The West Level and its companion roads in the Main Coal Seam continue for some 600 yards beyond the drifts. No coal was being worked in this area but it was used for training new entrants and was therefore known as the Training Section.

In the Five Quarter Seam from the top of the drifts, three roads, known as the Straight North places, with connecting stentons, continue to the north. From them, at about 200 yards from the top of the drifts, three roads, known as the First West Materials, Belt and Return roads, branch off and, still further to the north, are the roads forming the Second and Third West areas. From the Second West roads, a small area was formed into pillars which were then extracted. The Third West places were open but not working at the time of the explosion. It was from the First West Roads that the area chiefly affected was developed.

Up to the introduction of duckbill machinery in 1948, all these roads were driven by arcwall machines, the coal being blasted down and filled into tubs. The First South places were then driven, using duckbill loaders, into the reserved area. Pillars were formed but faulted ground curtailed further development. Full extraction was then attempted in the unreserved part, firstly by lifts off the pillars, and then by a modified form of longwall retreating, using the duckbill loaders. As neither method was completely successful, it was decided to use duckbill machines for winning out retreating longwall faces

to be worked by the conventional method of machine cutting, blasting and hand-filling on to conveyors. The Second South and Third South headings were driven in accordance with this decision.

The Second South headings, having been driven their full distance in readiness for the opening of a longwall face, were temporarily idle at the time of the explosion.

The Third South retreating face had been won out by two headings driven southwards off the First West Materials Road. Originally the headings had been set off 140 yards apart and the intention was to keep them parallel so as to form a face of that length, but the heading which afterwards became the return struck a fault and was turned inwards to avoid crossing it. Thus the two headings converged slightly, and the heading joining them to start the longwall face was 90 yards long. The longwall face began to retreat, by means of machine cuts four feet six inches deep, on 12th April. It had been decided to "cave" the roof in the waste so no packs were built, but at the waste edge a line of steel frame chocks, with mechanical releases, supplemented the wood props and bars. At the time of the explosion the face had travelled 37 yards.

The only other coal producing workings in the district at the end of May were three duckbill headings, Nos. 21, 22 and 24, which were being driven for the purpose of opening out a longwall face to the north of the First West return airway.

A road conveyor system, consisting of 30-inch belts, delivered all the coal to a central loading point on the West Level in the Main Coal Seam. The No. 1 trunk conveyor extended up the intake drift to the junction with the First West Belt Road where it was fed by No. 2 trunk conveyor, which extended the full length of the First West Belt Road. Feeding on to this conveyor were the Second South and Third South belt conveyors, a belt conveyor in No. 22 heading and scraper chain conveyors in Nos. 21 and 24 headings. All were linked by a system of sequence control.

The district was highly mechanised, the whole of the cutting and part of the loading being done mechanically, and the whole of the coal being conveyed mechanically. All the plant was electrically driven.

Normally, the longwall face was manned on the fore, back and stone-shifts and the duckbill headings on the back and night-shifts only. An average of some 325 tons output was obtained daily, half from the longwall face and half from the headings.

As part of the North Pit the district came under Mr. Emery's supervision. He was assisted in this district by a fore-overman, a back-overman and a master shifter, in addition to deputies and shotfirers.

Ventilation

Ventilation was produced by a steam driven Walker "Indestructible" fan, 22 feet in diameter. This fan was designed to pass 500,000 cubic feet per minute at six-inch water-gauge and at the time of the disaster was actually producing 423,000 cubic feet per minute at 5.5-inch water-gauge. An electrically driven Sirocco fan, 133 inches in diameter and of similar characteristics, acted as a standby. Both fans were situated on the surface and were connected by fan drifts to both the South and the West shafts.

The ventilation of this mine was complicated by the fact that a very long leg, extending seawards in the Hutton Seam and through a fault into the Low

Main Seam to a total distance of four miles from the shafts, had to be balanced against the much nearer districts in the upper seams. As a consequence the air flow in these latter districts had to be closely regulated to ensure that sufficient ventilation reached the far under-sea workings.

The system of ventilation of the Duckbill District itself is shown in Plan No. 1. According to the last air measurements made before the disaster, those on 16th May, a quantity of 23,200 cubic feet per minute was reaching the top of the intake drift. Of this 7,700 cubic feet per minute travelled to the idle places in the Third West District. Quantities of 11,000 cubic feet per minute and 3,900 cubic feet per minute passed along the First West Materials and Belt Roads respectively. A quantity of 5,500 cubic feet per minute was taken from these currents to ventilate the standing places in the First South District and this passed through air crossings direct to the First West Return. The Second South places were ventilated by a current of 4,300 cubic feet per minute passing inbye on the Materials Road and through two fans in parallel to the heading faces. This current then returned to the West Materials Road and most of it passed along the Third South Materials and Belt Roads to the longwall face and outbye along the return. Some air may have reached the Third South intakes and the longwall face by passing along the West Materials Road and the extension of the Second South Materials Road to the West Belt Road. On 16th May the quantity reaching the longwall face, where the ventilation was restricted by a fall, was 3,200 cubic feet per minute.

At that time Nos. 21 and 22 headings were ventilated through a breeches tube by an auxiliary fan situated on the Belt Road. Alongside this fan there was a canvas door.

Between 16th May and the time of the disaster important changes occurred. The fall on the longwall face was cleared. The fan ventilating Nos. 21 and 22 headings was transferred to No. 21 stenton and the door in the Belt Road was then removed. Farther along the Belt Road another fan was installed to ventilate No. 24 heading ; up to the time of the disaster this had been run only intermittently. On 28th May a second fan was installed in No. 21 stenton, so that Nos. 21 and 22 were ventilated separately.

Lighting

Oldham Type G.W. Electric Cap Lamps were used throughout the mine. The flame safety lamps in general use by workmen as gas detectors were Patterson A.1. (magnetic lock) and Patterson A.3 (lead rivet lock), the latter being in process of conversion to the former type by the lamproom staff as and when the necessary parts became available. Ringrose CH4 lamps were available as automatic detectors but were not used. The officials were supplied with either Wolf Patterson (internal relighter) 7 R or Baby Wolf 7 R.M.B.S. flame safety lamps for gas testing.

Precautions against Coal Dust

The only means of dust suppression in the district were sprays, not in any way enclosed, at the loading point and at three of the transfer points. It was said that each spray delivered about six gallons of water per hour. The suppression of dust by wet cutting and water infusion, which had been carried out satisfactorily in other parts of the mine, had not proceeded beyond experimental stages in the Duckbill District. The cleaning up of coal and coal dust and the spreading of stone dust were done partly by a stone dust team, which visited in turn all the districts of the mine, and partly by men regularly employed in the district. The team, under the charge of an official known as the stone

dust man, consisted of seven men and their duty was to clean the floor and sweep the girders and sides, filling the dust into tubs or sacks, and then to apply stone dust.

On the fore-shift a man was employed to clean the conveyor structures and to spread stone dust, and on the back-shift a man dusted the roads near the face.

On the stone-shift eight to ten men were wholly employed, and others spent part of their time, in clearing spillage and stone dusting. They began at the loading point and at the several transfer points and worked towards each other. Spillage was also cleared by the men engaged at the loading point. The total quantity of stone dust supplied to the mine as a whole was 40 tons per month.

The sampling of dust for the North Pit was done by one man who was fully engaged on this work. He took 102 samples each week.

III.—NARRATIVE OF THE EXPLOSION

General

The explosion happened at 4.35 a.m. on Tuesday, 29th May. By a tragic trick of fate this was a time when there were two shifts of men in the district, 38 belonging to the stone-shift and 43 to the fore-shift. Only one of these men was rescued alive, and he died of his injuries a few hours later. According to the medical evidence, all the others, mercifully, died almost immediately.

The names of the victims are given in Appendix I and Plan No. 2 shows where the bodies were found. Two members of rescue teams lost their lives in the recovery operations and so in all 83 persons were killed in the disaster.

None of the 895 persons at work in other parts of the mine was seriously affected.

Discovery and Preliminary Exploration

We have unfortunately no direct evidence of what happened on the shift of the disaster. The men on the stone-shift, who were due to leave the district at about 5.0 a.m., had been engaged in coal cutting on the retreating longwall face, in erecting permanent supports in the duckbill headings, in building an air crossing at No. 22 stenton and in stone dusting. The fore-shift went underground at 3.30 a.m. and in the ordinary course of events the fillers would have arrived at the face before the explosion occurred. The fact that none had done so suggests that they had been kept back because the conditions on the Third South longwall face were not normal, but, whatever the reason, it does not seem to have given rise to any great alarm for those outside the district received no appeal for help. The first intimation of disaster was a loud bang followed by a cloud of dust.

Frank Leadbitter, a shaft wagon-way man, who was just outside the shaft-bottom stables, acted promptly and, though the dust was so thick that he could not see, led the men working with him to the shaft bottom, and within a few minutes had telephoned a report to the undermanager, Mr. Emery, at his home. He then returned inbye to the West Main Curve and tried to get in touch with the Duckbill District by telephone, but getting no response telephoned a warning to the men at the South haulage junctions. Soon after he was joined by William Cook, fore-overman in the Seven Quarter and Old Five Quarter Districts, who had heard a sound like a heavy fall when he was

in the Seven Quarter engine house and had come 500 yards through a thick cloud of dust to investigate. After hearing Leadbitter's story Cook telephoned to Mr. Hopkins, the manager, and arranged for the withdrawal of the men from the rest of the mine. Then very gallantly he and D. Smith, a head wagon-way man, went along the Main Coal West Haulage Road in an attempt to get to the Duckbill District. About half way to the main loading point they heard what they thought was another explosion and felt the air current reverse. Not unnaturally they started to go back but, as the ventilation soon resumed its normal course, turned again inbye.

I am satisfied that what these two men thought was a second explosion was, in fact, an extension of a fall that they reached shortly afterwards. But I have no doubt at all that they believed it was an explosion and it is to their great credit that they went on in spite of what they must have felt about the risk of further explosions. About 150 yards from the loading point they came to a large fall and quite properly decided that it would be foolhardy to attempt to get over it by themselves. They therefore returned to report, and near the West Curve met the undermanager, Mr. Emery.

Meanwhile, amongst other emergency measures taken on the surface, a call had been made on the Central Rescue Station at Houghton-le-Spring. At 5.30 a.m. when the first team arrived underground they were sent almost immediately to examine the fall. Finding it impassable they returned and were sent to explore the West Main Coal Return. It was, however, thought unlikely that rescue operations would be possible by this route and when Mr. Fry, the Area General Manager, arrived it was decided to employ colliery workmen to make a road through the fall with the utmost speed and to explore the airway from the Seven Quarter Second South District, for this connected with the Duckbill District return drift where it passed through the Seven Quarter Seam. This road proved to be quite travellingable and though some props and doors had been blown out, Mr. Fry, Mr. Emery and Station Officer Adamson reached the Duckbill Drifts without much difficulty. Further progress was impossible without the use of rescue apparatus. The air was quite still, indicating that the air crossing at the foot of the intake drift had been damaged. The separation doors in the stenton connecting intake and return had been destroyed and the air was so foul with afterdamp that the canaries carried by the party were overcome almost immediately.

Rescue and Recovery

Clearly rescue operations had to be organised immediately to deal with a disaster of the first magnitude. Arrangements were made, therefore, to establish a fresh air base in the Second South Seven Quarter airway about 100 yards back from the Duckbill District return drift. This was by no means an ideal site, for materials had to be manhandled for considerable distances, both in getting them to the base and on to the place of use. However, there was no alternative until a travellingable road could be made over the fall on the West Main Coal Level, and in spite of the difficulties the first team left the base (marked on Plan No. 2 as the First Fresh Air Base) just after 8.0 a.m. to explore outbye along the intake drift. Near the loading point they found a datal hand, Matthew Williams, alive but so badly injured that, as mentioned earlier, he died a few hours later. They saw the bodies of several other men and found that the air crossing had indeed been destroyed.

This team and others following reported that the stoppings between intake and return had been destroyed over a large area. It was decided, therefore, to arrange for two teams to operate simultaneously, one sealing off at selected points to re-establish ventilation and the other extending to the utmost the

search for possible survivors. This arrangement worked well for a time and one of the exploring teams penetrated to the end of the Straight North headings, a distance of about 1,100 yards. However, J. Y. Wallace, the captain of a colliery rescue team, lost his life in exploring in the First West roads, and it was then decided that the brigades were penetrating too far into the irrespirable atmosphere and, therefore, that both teams should be used to restore the ventilation.

So far all the operations had been carried out from the original base in the Seven Quarter airway. By noon the next day, 30th May, after the ventilation had been re-established in the drifts up to No. 2 stenton, the Training Section in the Main Coal Seam sealed off, Main Coal Level, the fresh air base was advanced to a point just outbye of No. 2 stenton.

By midnight the fresh air base had been advanced to No. 14 stenton on the First West Materials Road, travelling being easier on this road than on the Belt Road. As no survivors had then been found and as samples of the atmosphere brought back by the exploring teams were highly lethal, it was agreed by all parties that there was no longer hope of finding anyone alive.

Before any further advance could be made, it was necessary to increase the quantity of air reaching the fresh air base. The foul air in the First South District was sealed off and air crossings were erected to carry any seepage direct to the return.

At this time a cover base was set up at the First West Materials Road junction. This permitted adequate reserves to be kept close to the fresh air base and allowed oncoming brigades to rest before going forward for active duty.

About 7.45 a.m. on 1st June, the fresh air base was moved in to No. 16 stenton and exploration along both belt and return roads reached No. 25 stenton. Some two hours later H. Burdess, a member of a rescue brigade exploring the inbye end of the First West Roads, collapsed and died. At the time it was thought that he might have been affected by having to pass a number of dead bodies, and, though it slowed down the rate of advance, arrangements were made to bring out all the bodies on the line of travel. Further difficulty arose when it was found that the West Materials Road was blocked by a large fall ahead of No. 20 stenton. To by-pass this, the fresh air base was transferred to the Belt Road.

On 2nd June the base was advanced to the junction of the Belt Road and the Third South Materials Road. Brigades erected stoppings at the entrance to the Second South Headings and built a tube air crossing over the Third South Materials Road so as to convey any afterdamp seeping from this area into the return airway at No. 26 stenton.

On 4th June the base was advanced to just outbye of the junction of the Third South Materials Road with No. 27 stenton ; more bodies were recovered and the Third South face was explored to where it was closed by a fall about 17 yards from the conveyor gate. Both 27 and 28 stentons were also closed and though an attempt was made to clear a road through them, it soon became obvious that little further progress could be made by men wearing apparatus. Colliery workmen were then brought in, but when afterdamp began to leak into the Materials Road at the tube air crossing it was decided to withdraw everybody and clear the afterdamp from the First and Second South areas. Teams re-ventilated these areas in turn and at 6 a.m. on 7th June it was possible to re-establish the base at No. 27 stenton. A way was made over the fall in

this stenton on 8th June but the air in the return was found to be foul. However, when rescue men started clearing the fall in No. 28 stenton air began to drift over it. By 8.0 p.m. the ventilation was re-established and the whole of the Third South had been cleared of afterdamp. The rescue teams were then withdrawn to the outbye end of the First West Materials Road and from there they inspected the Straight North and the Third West headings and found them clear. At 9.45 p.m. on 8th June, their task completed, they withdrew from the mine.

The rescue operations covered a period of 257 hours, during which time 11 officers, 48 permanent corps men and 291 trained colliery rescue workers were engaged. Between them, these men wore apparatus 1,168 times and 13,277 pounds of liquid air was used.

Later I shall have to make some comments on the circumstances connected with the deaths of J. Y. Wallace and H. Burdess. In so far as I may appear to criticise, it will be solely in the hope that what I have to say will contribute to safety in future, and I wish to make clear beyond all question my great admiration of the way in which the rescue teams worked. It may be that the temperatures were not excessive nor travelling conditions unduly arduous, but the work was prolonged, the distances travelled considerable and the atmosphere so lethal that anyone making a mistake or taking a liberty was likely to pay for it with his life. Nevertheless, and in spite of the death of two of their comrades, these men never faltered and their morale throughout was maintained at a level that reflected the greatest credit on them as individuals and on the system in which they had been trained.

Tribute must also be paid to the large number of colliery workers who man-handled supplies to fresh air bases and with each move forward removed bodies, strengthened stoppings and cleared paths. Their work, though not so dangerous as that of the trained rescue teams, was arduous, unpleasant and not without strain, and I am glad to have the opportunity of recording sincere appreciation of their services.

Investigation of the Affected Area

(a) Method

Investigation went on concurrently with the work of the rescue teams but it was not until 9th June that an inspection could be made of the whole of the area in the Five Quarter Seam. The Training Section in the Main Coal Seam remained sealed until the end of August.

Immediately on returning from a tour of duty, each rescue team made reports from which the surveying staff marked on plans the position of bodies and other information. A staff of surveyors and one or more of H.M. Inspectors of Mines were in constant attendance at the fresh air base and they followed each advance as it was made, noting and marking on plans all signs of violence and of the passage of flame. Much of this information is shown on Plans 2 and 3.

A detailed examination of the area from the aspects of passage of flame, signs of coking and residual dust was made by Dr. Tideswell and his colleagues, Dr. Woodhead and Messrs. Shaw and Bradshaw, of the Safety in Mines Research Establishment.

H.M. Inspectors of Mines collected samples of dust, in the way prescribed by the Regulations, over the whole area affected.

All electrical plant was examined on site as soon as practicable and all damaged or defective pieces of apparatus found were taken to the surface for

further examination and, where necessary, for test at the Safety in Mines Research Establishment. All the conveyors were examined for signs of heating and all safety lamps found were collected and sent for test, as also were two pairs of chock releases found in the tripped condition. The five auxiliary fans were brought to the surface and examined by Mr. A. E. Crook, H.M. Principal Inspector of Mechanical Engineering, and later by Mr. H. Robinson of the Safety in Mines Research Establishment.

(b) Conditions on the Roads

There was little evidence of severe mechanical damage to the supports and structures on the roadways, but many supports had been dislodged and roof falls were numerous and extensive. Examination of the supports remaining in position showed that the loads on them were by no means high, and it is probable that the falls were caused by the explosion pressure dislodging lightly loaded props. There was evidence that some falls had occurred during the actual explosion ; some had extended after the explosion.

The bodies, except for five on, or in the vicinity of, the longwall face, were found at widely separated parts of the roads. Most of the fore-shift men were on the Third South Materials Road.

(c) Conditions on the Longwall Face

A very severe weight had occurred on the face which was closed by a fall of roof extending from some 12 yards to 27 yards from the intake and, except for a few yards at each end, the remainder of the roof was fractured and displaced (see the cross-sections on Plan No. 2). Many of the wood props and bars and many of the wood chock pieces were broken. Nine of the mechanical releases with which the chocks were equipped were found " tripped ". A few feet behind the chocks the roof had fallen, mostly in large blocks, to a height locally at least ten feet above the seam.

The coal cutting machine was found about 12 yards from the return gate in circumstances which left little doubt that it was cutting when the explosion happened. The bodies of the three machinemen were several yards nearer the return roadhead. The control handle was in the full " on " position, the haulage and cutter chains were in gear and the kirvings were close up against the jib. An examination of the cable supplying the gate-end box showed that it had been damaged at a point near No. 27 stenton whilst live, the blow received causing a short circuit. In view of the violence needed to cause the damage found—the wire armouring had been pierced and brick dust was found even in the insulation of the cores—there can be little doubt that the cable must have been struck, whilst still passing current to the cutting machine, by a brick propelled by the blast of the explosion.

The bodies of two stonemen were discovered at the face about 30 yards from the intake road and those of two others at the intake roadhead near that of the master shifter, J. Charlton, whose relighter flame safety lamp was found nearby. The flame safety lamp belonging to J. Godsmen, one of the cutter men, was found in the Belt Road some distance back from the face. No flame safety lamp or other means of detecting firedamp was found on the face.

(d) Passage of Flame

The spread of flame (see Plan No. 3) was exceptionally large, amounting to roughly 16,000 yards, though as Dr. Tideswell stated, signs of severe burning were few and local. Indications of its passage were found in almost all parts of the Duckbill District and there was also evidence of flame in the Main Coal Workings 500 yards west of the foot of the Drift. On the West Main Haulage

Road flame travelled about 100 yards east of the foot of the Drift. No signs of flame were found in the Third South Materials Road south of No. 27 stenton, the Third South Belt Road for 150 yards south of this stenton, and No. 29 heading. Plan No. 3 also shows where signs of coking were found.

(e) Direction of Blast

There was general agreement on the direction of the main blast of the explosion. It was outbye on all roads in the First West area east of No. 21 stenton and down to the West Level, except for the projection westwards along that road. The Second South, First South, Straight North and Third West areas all showed directions of blast pointing from this main path. In this path of the explosion from outbye of No. 18 stenton the blast traversed the intakes first and burst through the stoppings in the stentons towards the return.

Inbye of No. 21 stenton the indications were less consistent. The two intakes of Third South showed a general blast towards the face, but in the return the direction of blast was outbye, except for a stretch between No. 26 and No. 27 stentons and one near the face. In all the stentons inbye of No. 18, the blast was from the return towards the intake. In Nos. 21, 22 and 24 headings the explosion was towards the faces of the headings. At the junction of No. 22 heading with the return, blast radiated in all directions.

As is usual after an explosion, everything was found to be covered with "explosion" dust, which had been raised up by the blast and had subsequently settled. This deposit, Dr. Tideswell stated, was of varying thickness and appearance but averaged 1/50 inch in thickness. Examination under the microscope showed that much of it had been subject to flame. Some 400 samples of this dust were tested in the laboratory. Nearly 300 of these were grouped as being those least likely to have been contaminated with dust other than that which had been raised in the explosion cloud, and with few exceptions they contained between 30 and 55 per cent. of incombustible matter.

Mr. W. J. Badger, H.M. District Inspector of Mines, sampling in accordance with the Regulations, collected 163 samples. Of the 28 samples taken in the Training Section of the Main Coal Seam 25 contained less than the minimum 75 per cent. of incombustible matter required by the Regulations. Of the 135 samples collected elsewhere in the affected area, 113 were found to be up to the required standard.

IV.—CAUSE AND DEVELOPMENT OF THE EXPLOSION

Point of Origin

In the light of the evidence it was agreed by all the parties concerned in the Inquiry that the point of origin of the explosion was at the retreating longwall face. There were other places, such as the junction of No. 22 Duckbill heading with the return, at which the lines of force indicated a possible origin, but in none of these, in fact in no place other than the longwall face, was any possible igniting source found.

Means of Ignition

Although electricity was so widely used, the evidence showed that it was not the means of ignition. Though some damage and defects were discovered in the electrical plant, it was shown either that they had been caused by the explosion itself, or that they were in such a position that they could not have given rise to the explosion.

In a careful examination no contraband whatever was found.

All mechanical appliances such as conveyors were examined but no signs of frictional heating sufficient to have served as a source of ignition were found.

The position of the shot firing cables and exploders showed that no shots were being fired at the time of the explosion. Evidence was given that shots had been fired in the roof at the longwall face to release chocks on some previous shifts and that on Sunday morning, 27th May, a shot hole was seen to have been bored for such a purpose, though it had not then been charged. Mr. Emery, inspecting about 8.0 a.m. on the following day, formed the impression that a shot had been fired near a chock. It seems to me unlikely, however, that if firedamp had been ignited by any such shot it would have continued to burn unseen when the heavy falls of roof occurred in the waste during the drawing-off operations on the evening prior to the explosion.

The safety lamps belonging to the men who were at or near the face when the explosion happened were found in a damaged condition, and there is of course no means of knowing what they were like beforehand. But as they were all damaged, and as the general standard of maintenance of the lamps was very high, it is reasonable to assume that the damage had been caused by the explosion.

There is the possibility that gas was ignited by sparks caused by rock falling in the waste, but no such sparks had ever been reported and, in my view, it is improbable that this did in fact happen.

It was proved that sparking did sometimes occur during the operation of the chock releases and a number of chock releases were found in the released state after the explosion. However, in tests made some years ago by the Safety in Mines Research Establishment on releasing chocks under load in an explosive atmosphere, and recently repeated under much bigger loads using a pair of the chock releases discovered to have operated spontaneously on the longwall face, no cases of ignition of firedamp occurred.

On the other hand, the evidence is that the coal cutter picks were moving at the time of the explosion, that they were then cutting through pyrites, and that sparks from this pyrites proved, under test by the Safety in Mines Research Establishment, readily capable of igniting mixtures of firedamp and air. Moreover, sparking had frequently been seen in other districts of the seam when a cutter jib was exposed during jibbing in, and on one occasion sparks had been seen in the undercut on this particular face.

I have no hesitation, therefore, in finding that the ignition was due to sparks caused by the cutter picks striking pyrites—a conclusion which was accepted by all the parties represented at the Inquiry.

Explosive Medium

From the position of the igniting source as well as on general grounds, it was agreed by all parties that the initial explosion was one of firedamp.

(a) Source of Firedamp

In considering the source of the firedamp, it is necessary to refer briefly to the roof conditions on this retreating face since it was started on 12th April.

After the face had travelled some 15 yards, that is to about 20 yards from the back rib side, some three to four feet thickness of roof fell in large pieces in the waste. On 27th April a heavier weight occurred causing a further fall of large stones in the waste and the breaking of many props at the face. After this, cutter breaks usually formed in the roof along the successive face lines and the withdrawal of the supports became difficult. On 11th May, when it had moved 32 yards, the whole of the face except near the ends was affected by a much heavier weight and ten yards of it was closed. In the waste a considerable thickness of roof fell again, mostly as large stones. The face was not fully re-opened until 21st May. From then up to the time of the explosion it advanced $4\frac{1}{2}$ yards.

During coal filling operations on Monday, 28th May, breaks were observed in the roof at the face on the length of about 20 yards between the intake roadhead and a slip plane. During the day a break displacing the roof downwards on the goaf side developed along the face on the return side of this slip. On the back-shift, after the loading of the web of coal had been completed, the chocks were advanced and props and bars withdrawn. This was followed by falls of roof in the waste and by further displacement of roof along the break near the coal face, but about 8.0 p.m. the roof steadied and shortly afterwards the last of the back-shift workmen left the face feeling that it was quite secure.

There is indirect evidence, however, that further trouble occurred during the night-shift. Usually cutting was completed between 2.0 a.m. and 3.0 a.m., but when the explosion occurred at 4.35 a.m. 12 yards remained to be cut. Moreover, though men normally working in the duckbill headings were sometimes sent to the face to load cuttings, the presence at or near the face of four stone-men and the master shifter, together with the fact that the fore-shift workmen had not proceeded to the face, provides strong circumstantial evidence that the roof had again been "on weight".

Considering the reasons for the occurrence of this weight, it seems to me that as the face advanced, the roof over the waste, being without direct support, would be carried on abutments in the solid coal sides, in the coal left behind, and in the coal ahead of the face. With the continuing advance the span over the goaf and consequently the abutment pressures would increase and some roof beds would lower and fracture. An attempt to show the trend of these occurrences, though not the actual happenings, is made in Diagram 1.

Although the immediate roof behind the waste edge supports collapsed in layers, the stone did not break up much in falling, and Mr. Emery, Mr. Hopkins and Mr. Morgan agreed, when questioned by Mr. Jones, that the conditions which developed were not those in which caving was likely to be successful.

As the seam was nearly seven feet thick it seems evident that the heaps of debris cannot have been high enough to give support to the unbroken beds above them. I envisage, therefore, that even after the weighting of 11th May, a considerable cavity in the goaf area was spanned by the higher beds.

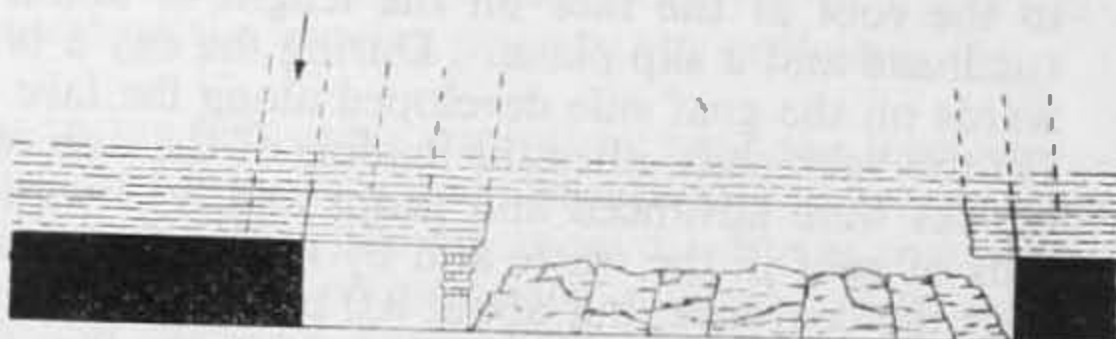
It is likely therefore that during the night of the disaster the higher beds, overstrained by their increasing span over the goaf and affected perhaps by the comparatively slow advance since 11th May, and under the influence of the cut being made at the time, lowered gradually and finally fractured. Many props broke under the extra pressure and falls occurred, but most of the chocks remained effective and limited the extent of the falls. That the weight continued after the explosion is shown by the fact that some of the surfaces of the chock blocks exposed by fracturing were not coated with dust.

DIAGRAMMATIC REPRESENTATIONS OF ROOF MOVEMENTS ON LONGWALL FACE.

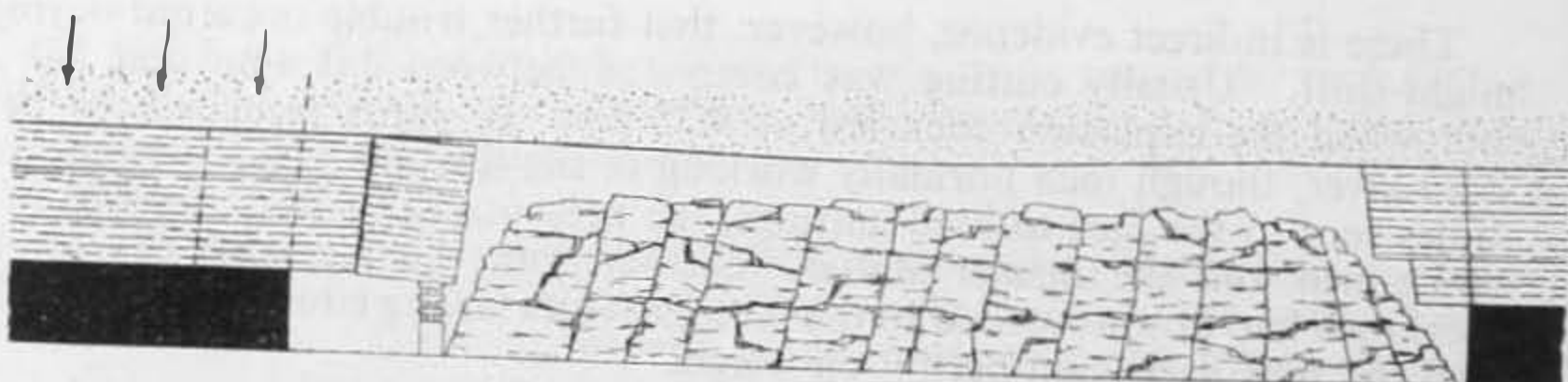
(BY VERTICAL SECTIONS THROUGH THE CENTRE OF THE FACE)



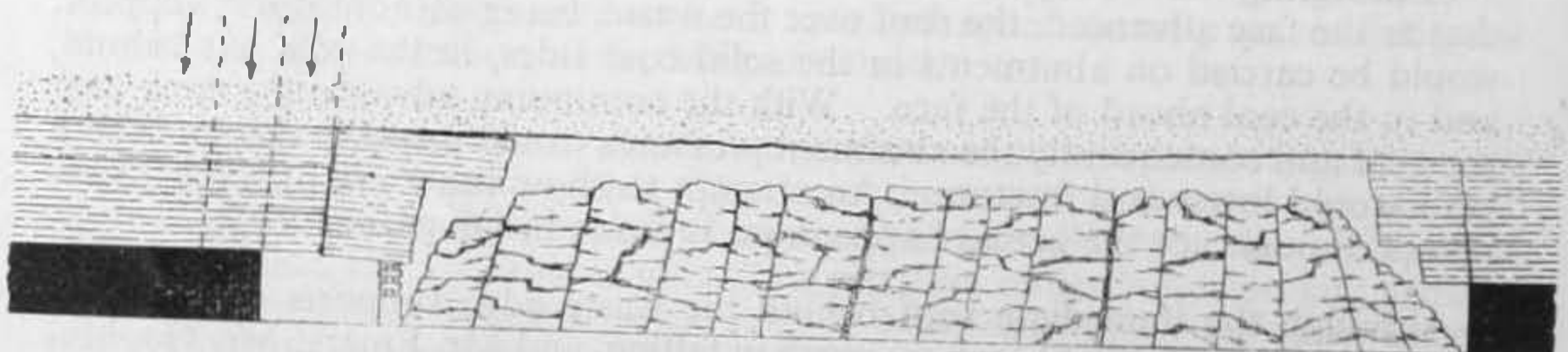
ORIGINAL HEADING



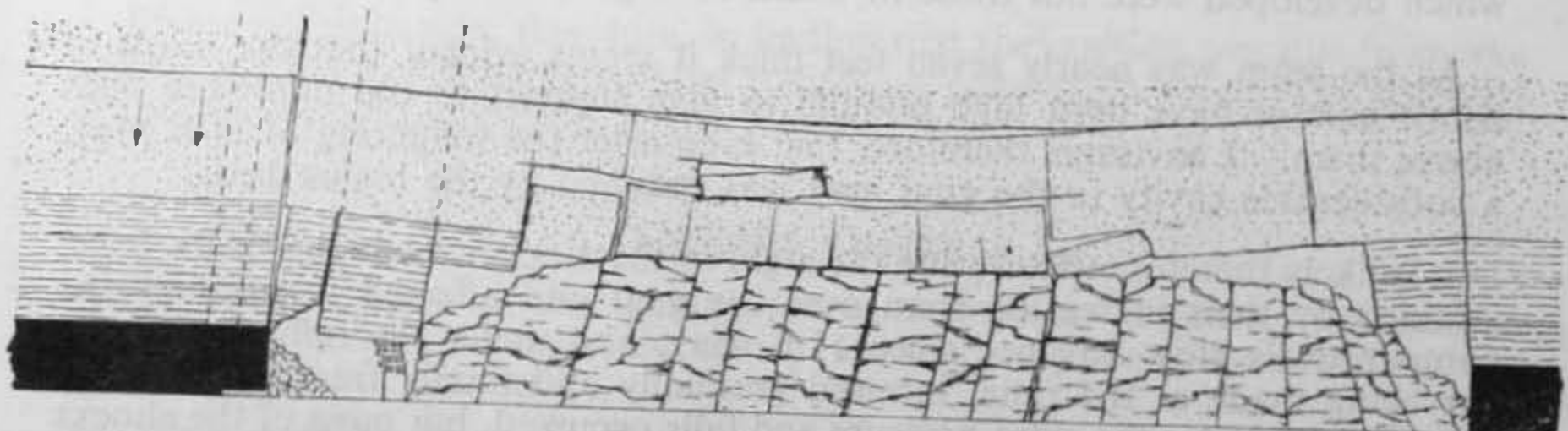
AFTER FIRST ROOF FALL IN WASTE



AFTER ROOF FALL ON MAY 11TH



CONDITION ON AFTERNOON OF MAY 28TH.



CONDITION AFTER WEIGHT

DIAGRAM I.

(b) Emission of Firedamp

Whilst all parties agreed that the firedamp came partly from the waste and partly from the higher beds, there was a wide difference of opinion as to the contribution made by each source. Mr. W. H. N. Carter, H.M. Senior Inspector for Special Duties, thought that the firedamp had in the main come from cavities in the waste and that the emission was on the whole gradual. On the other hand, Mr. H. E. Collins, the Production Director of the Durham Division of the National Coal Board, and Mr. H. F. Wilson, H.M. Senior District Inspector of Mines in charge of the South Durham District, thought there had been a sudden and very large outburst from the roof strata.

Considering the possibility of emission of firedamp from the waste, the space created by the removal of the coal was roughly 300 feet in length, 100 feet in width and six feet in height, that is about 180,000 cubic feet. Except in so far as this cavity had been reduced by the lowering of the roof strata massively, as opposed to the falling of the immediate roof which would merely transfer the space slightly upwards, it would remain open, a potential reservoir for firedamp, with a ready path to the air coursing the face.

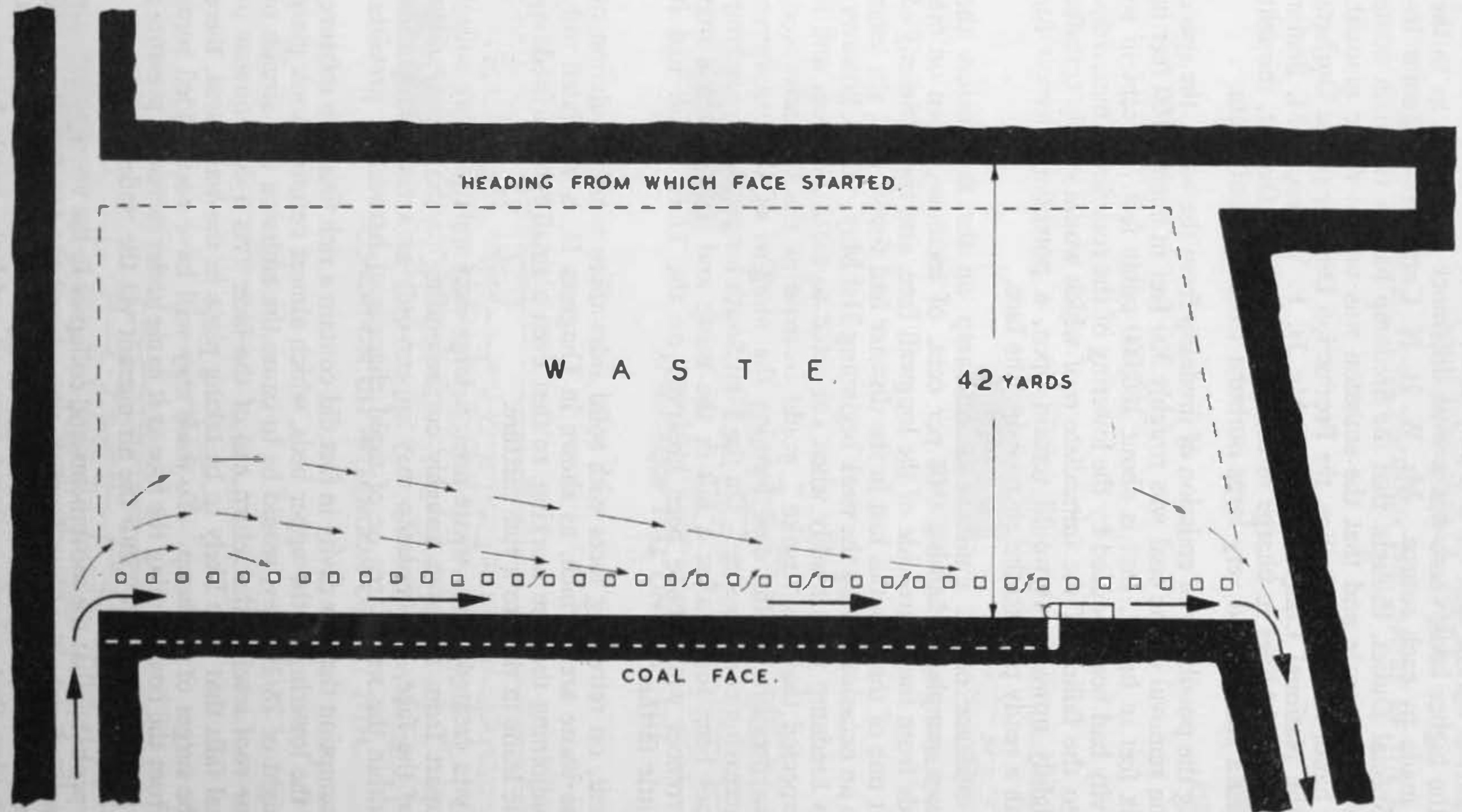
The only evidence of the emission of firedamp on the face before the explosion was a sample, containing 0.08 per cent. of methane, taken on 6th May ten yards from the return side of the longwall face, and the testimony of one man that one of the deputies lost in the disaster had found it at the edge of a break on an occasion during the week beginning 21st May. Coal, however, usually emits firedamp most readily when subjected to extra pressure, and it was to be expected that the "make" would increase as the face advanced, and the extra pressure on the coal forming the margins of the excavation became of increasing consequence. On the First South longwall face firedamp had sometimes been found after a fall in the waste and it is probable that similar occurrences would have been observed on the Third South had it travelled a little farther.

In any event, on retreating faces with solid sides there is no circulation of air across the waste area, which, as shown in Diagram 11, is ventilated only at the edge adjoining the face working, so that even a small flow of firedamp into the waste leads in time to a rich mixture.

If cavities are created in the waste area, a large accumulation may collect there, but, apart from an issue, roughly corresponding to the make, at the return end of the face, the firedamp may appear only as a result of ground movement within the waste area or of rapid changes of barometric pressure.

On the assumption that the cavity in fact did contain a rich firedamp mixture, the effect of the lowering of the upper beds, which almost certainly took place during the night of 28/29 May, would be to cause the emission of a stream of firedamp near roof level at the return end of the face. As a consequence of the occasional falls that were likely to be taking place in the waste area, there would also be surges of firedamp. To these may well have been added some extra make from the coal forming the face as it came under increased pressure ; part of this would find its way into the air current via the undercut.

It is quite probable that the movements and collapses in the waste would also create channels whereby firedamp from the thin seams 136-185 feet above the Five Quarter Seam may well have made a contribution to the emission. I reject, however, the view that a large outburst occurred suddenly, partly because a gradual issue from the waste is more in accord with general experience, but more for reasons I advance in the following section.



ILLUSTRATING PROBABLE CONDITION OF
VENTILATION OF LONGWALL FACE AND WASTE AREA

DIAGRAM II.

Spread of the Explosion

Two widely differing views were put forward as to the reasons for the spread of the explosion outbye. Mr. Collins contended that the large volume of firedamp under high pressure, which he envisaged to have been released when the waste collapsed, was practically simultaneously ignited and that it carried the explosion through the whole of the affected area, with coal dust playing but a minor part. On the other hand, Dr. Tideswell envisaged a gradual emission of firedamp causing a considerable length of the return airway to contain an explosive mixture ; when this was ignited it burst through into the First West intake roads and there initiated an explosion of coal dust which continued through the rest of the area.

Mr. Collins based his opinion on five main factors :—

- (1) The absence of excessive explosion violence.
- (2) The very light deposits of coke and the absence of coking over quite long lengths of roadways, particularly the outbye lengths of the First West Roadways.
- (3) The peculiar effects of the explosion in the Training District of the Main Coal Seam. (Here he was referring to the fact that there were signs of burning of props and brattice cloth in the Training Gallery although no evidence of burning was found in the roads leading to it.)
- (4) The uniformity with which the flame traversed the roadways throughout the New West Duckbill District and particularly the fact that these flames travelled along the returns.
- (5) The results of the analyses of the post-explosion residual gases and the deductions drawn therefrom.

I see nothing in the first three factors at all peculiar to explosions of firedamp ; similar effects have been noted in previous explosions which after full investigations have been accepted as explosions of coal dust.

The uniformity with which the flame traversed the various roadways is, I think, what might well be expected, bearing in mind the very numerous connections between intakes and returns and that, almost without exception, the stoppings in these connections were destroyed.

The fifth factor refers to an attempt on the part of Dr. Jones, the Divisional Chief Scientific Adviser, to determine the nature of the fuel giving rise to the explosion from the composition of the residual gases. The method depends on the fact that when a fuel burns, the hydrogen combines with the oxygen in the air to form water, which condenses, so that it is possible from a comparison between the gaseous products of combustion and the amount of oxygen consumed to arrive at the proportions of hydrogen and carbon in the fuel.

In the laboratory this is a well established method of distinguishing between different hydrocarbons, but it has not previously been used as a means of determining the nature of the fuel taking part in an underground explosion. The method has possibilities, but as yet little is known about the variations resulting from the known instability of the oxides of carbon in a mine and from the absorption of oxygen by coal. Moreover, Dr. Jones himself made it quite clear that any conclusions based on the analyses of residual gases were valid only for the area in which the samples were taken, that is inbye of the First South headings.

Mr. Collins, however, suggested that as the conditions outbye of First South differed in no material sense from those inbye it was reasonable to assume that there was no difference in the explosive medium. But in fact the conditions differed very significantly in that in all the stentons inbye of No. 18 the indications of direction of force pointed from the return towards the intake, whereas in the stentons outbye from there the force had travelled from the intake towards the return. Mr. Collins thought that the explanation of this very important difference was partly that as the explosion travelled along two intake roads as compared with one return road, the force towards the return would be greater than that away from it, and partly that the explosive violence which occurred at the junction of the return with No. 22 stenton would tend to retard the explosion wave in its passage farther outbye along the return. He said, however, at another point, that he was "definitely of the opinion that the initial explosion caused the falls in the face return, in stenton 28, and that it blew the stopping in stenton 27, the stopping in stenton 26, the doors in the extension of the Belt Road towards the return, and finally passed along the return towards 22's heading". If, as Mr. Collins believed, the explosion was propagated by a fast moving column of firedamp with a burning front it is surely to be expected that when the explosion blew through into the intake at No. 26 stenton and at the belt extension, the postulated effect of the spread of the explosion along the twin intakes, as well as the "further development of explosive violence", should have become evident there and the subsequent direction of force outbye of this point should have been towards the return. But in fact the direction of force in the stentons inbye of No. 18 was from return to intake and the signs of explosive violence were at the junction of No. 22 and the return. I therefore reject his explanation of the change in direction of the blast.

Finally, I find it quite impossible to accept the mechanics of a theory by which in effect an almost solid body of firedamp with a burning front propagated the explosion through the whole of the affected area by picking up oxygen as it advanced. This view is perhaps strengthened by Mr. Collins' replies to questions which I put to him :—

" Q. What volume and rate of emission of gas have you envisaged ?

A. Well, I said earlier, Mr. Commissioner, that I agreed with Dr. Jones' estimation of 100,000 cubic feet. My own rough and ready estimation made it 120,000 cubic feet. I think this gas emission came off very, very quickly, and I can only say that I have no guide as to the rate of emission. I should imagine that the full emission was complete within a very few minutes. I cannot say any nearer than that, and that is merely an opinion.

Q. I may be mistaken, I am speaking from memory, but I rather imagined that 100,000 cubic feet included his calculation for the area outside 21. Is that correct ?

A. That is correct.

Q. And that he was not prepared to hazard any opinion at all whether it was firedamp or coal dust ?

A. I think that was the position, yes.

Q. To go back to this question of a large volume being produced in a very short time, would not that have produced a complete blanketing of the atmosphere which would indicate ?

A. It would, except that, as I visualise the position, may I put it this way. I think the source of ignition was there waiting for the gas to come off. In other words, the coal cutter was cutting the whole time and the ignition of gas took place simultaneously, or roughly simultaneously, with the actual gas emission, and that the flame front went up in front of the main body of gas ; and that it got its feed of oxygen from various points en route."

In my opinion even if such a process could continue, it would be only by fits and starts, with interruptions whilst admixture with fresh air was taking place. There was, however, no suggestion that the men in the First West intakes and on and about the drift were taken other than unawares by the explosion and it is reasonable therefore to infer that the explosion swept through the workings without significant halt.

On Dr. Tideswell's estimate that the flame reached the West level in the Main Coal Seam within 30 to 60 (or at most 90) seconds of being ignited, the outburst of gas postulated would have to be almost instantaneous and Mr. Collins himself estimated that it would be complete within a very few minutes. Assuming for the sake of argument, however, that it lasted five minutes and that the volume of air passing along the face was 5,000 cubic feet per minute, the atmosphere would contain 80 per cent. of firedamp. Such a mixture could only ignite in the very small fraction of time taken for the thin envelope of mixture containing between five and 15 per cent. of methane, at the front edge of the rapidly advancing gas, to pass over the source of ignition. I am very doubtful if it could do so, but again assuming that, as Mr. Collins suggested, the fringe did manage to ignite, I cannot believe that it would continue to burn. For at least the first 300 feet along the return this 80 per cent. mixture would have had to travel along a road in solid coal like a piston in a cylinder. As pure firedamp must be mixed with six times its own volume of air before it will burn, an 80 per cent. mixture would need between four and five times its own volume. Thus for every unit of the mixture burned there would be nearly six units of incombustible products and, being hot, they would occupy at least 20 times the volume of the original firedamp. There being no means of escape, a rapidly increasing wad of incombustible gases would gather between the advancing firedamp and the only supply of fresh air. Very soon, indeed almost immediately, it would become impossible for enough gas or air to pass across this wad to provide an inflammable mixture and the flame would die for lack of oxygen.

This analysis is, of course, quite unduly favourable to the hypothesis, for an emission of gas of 20,000 cubic feet per minute would have stopped the flow of air on to the face almost at once. In all probability the air would have been reversed and a part of the firedamp would have been forced into the intake roads where on the hypothesis it should have mixed with the air and burnt. In fact, as was brought out by Dr. Jones and Dr. Tideswell independently and supported by medical evidence, there was little, if any, combustion on the Third South intake roads near the face, and Dr. Jones gave evidence that little residual methane was found in these roadways as compared with elsewhere.

It is now necessary to consider whether the facts can be explained on the alternative theory that an initial gas explosion burst through to the intake and caused an explosion of coal dust.

Significant features of the initial explosion were the absence of flame in the intake in the neighbourhood of the longwall face, the development of violence

at No. 28 stenton, the direction of force being from return to intake as far as No. 18 stenton, and that the stopping in the extension of the return to the North Haulage Road was not destroyed.

Dr. Tideswell held that, to account for these features, at the time of the ignition fouling of air must have extended well along the return but not beyond No. 18 stenton, and that near the source of ignition it must have been a slow burning mixture. Estimating that the volume of the air passing along the face was of the order of 5,000 cubic feet per minute, he calculated that to produce such an inflammable mixture firedamp must have been issuing from the waste for a period of from ten to 20 minutes, or more, and that the volume of firedamp needed would be between 5,000 and 20,000 cubic feet depending on whether or not coal dust played any part in this phase of the explosion. For convenience in this calculation Dr. Tideswell assumed a uniform emission. It is, however, unlikely that the emission was uniform and, as diffusion would be slow in the current moving slowly along the unobstructed return, I think the gas would tend to persist in layers and that the concentration would vary from place to place. Moreover, as the path of the explosion crossed the conveyors in Nos. 24, 22 and 21 headings, it is reasonable to assume that coal dust did play some part in this phase. For these reasons, though the waste may well have contained a much larger volume of gas, I believe the effects observed may have been produced by a quantity approximating to the lower limit suggested.

Against this it was argued that such a large volume of firedamp could not have issued for so long without the three experienced machinemen working on the face becoming aware of it and taking some action. I believe the explanation is that :—

- (a) as indicated in Diagram 11 most of the firedamp would issue from the waste near the return gate ;
- (b) the machine was still 12 yards from the return roadhead when the explosion happened, and half an hour before, assuming normal cutting speed, it would have been 20 yards farther away ; and
- (c) the men had no means of detecting firedamp.

The difficulty, one might say the impossibility, of accounting for the fact that the force of the explosion had travelled from the return towards the intake inbye of No. 18 and from the intake towards the return from there onwards, on the theory that firedamp was the sole explosive medium, has already been discussed. But if, as Dr. Tideswell suggested, a coal dust explosion travelling along the intake was initiated by the firedamp explosion when it blew through at No. 26 stenton and the extension of the West Belt Road, the difficulty disappears.

The question then arises as to whether there was any evidence to support the theory of a coal dust explosion.

Dr. Tideswell estimated that there was a deposit of explosion dust—i.e. dust that had been raised into the air by the blast and subsequently deposited—about one-fiftieth of an inch in thickness corresponding to a cloud density of about 0.5 ounce per cubic foot throughout the area. As tests by the Safety in Mines Research Establishment showed that coal dust from the Five Quarter Seam required 60-65 per cent. of inert matter to render it non-inflammable, whereas most of the samples of the explosion dust contained only 35-50 per cent. of such matter, and as an explosion can be propagated by a cloud density of as little as 0.05 ounce of coal dust per cubic foot, he expressed the opinion that there was between two and three times as much explosive dust as was necessary to have carried on an explosion.

It is true, as Mr. Collins pointed out, that the samples taken by the management before the explosion and most of those taken by Mr. Badger afterwards contained considerably more than 65 per cent. of inert matter, and therefore it might seem that the dust should not have been explosive. These samples however were taken in the manner prescribed by the Regulations to determine the mean composition of the dust over the area of road sampled, whereas Dr. Tideswell's survey showed that the composition of the explosion dust which, it must be remembered, was the dust which had formed the cloud through which the explosion had passed, was much closer to that of samples taken deliberately from the more coaly deposits. This is quite consistent with the work described in Safety in Mines Research Board Paper No. 105* which shows that mine dusts are not uniform and that the mean composition of non-uniform deposits seriously under-estimates the inflammability of the deposits. In short, a far higher proportion of inert matter is needed to render dust non-inflammable when the coal dust and the inert dust are not intimately mixed.

Again, it was argued on behalf of the National Coal Board that, because of the work done in cleaning up, there were good grounds for thinking that there would not be enough dust available to propagate an explosion. Having regard, however, to Dr. Tideswell's estimate of the amount of explosion dust, and to the evidence of Dr. Tideswell, Mr. D. E. Edwards, H.M. District Inspector of Mines, and Professor Granville Poole, lately Head of the Mining Department, King's College, Durham University, who was called as an expert witness by the National Union of Mineworkers, on the presence, particularly round transfer points, of deposits of coaly dust after the explosion, I am unable to accept this view. Despite the clearing up and stone dusting which had been done, the blast would raise coal-rich dust from any coal or cuttings in transit on the conveyors, from the conveyor structures—which are notoriously difficult to treat or clean—from the belts themselves and from inaccessible places behind supports, etc.

It was said also that the amount of coking found in the area was small, and certainly much less than had been experienced at the Louisa Colliery explosion in 1947, and that this indicated that coal dust had played little part. Deposits of coked dust were, however, found widely even though lightly distributed inbye the top of the drift from the Main Coal. Dr. Tideswell held that the amount of plastered coke was about that usually found and that the amount and general appearance of the coked dust was consistent with an explosion travelling through a dilute and only moderately inflammable cloud of mixed coal and stone dust in air. Against this Mr. Collins contended that the coking nature of the Five Quarter Seam would account for the presence of signs of coking in the explosion dust even if the explosion was a pure firedamp explosion, i.e. that the propagation was not due to the inflammation of the dust itself. The fact is that it is not possible to say from a superficial examination of an affected roadway whether an explosion had been one of coal dust or firedamp. Explosions of either give rise to widely differing degrees of violence; a coal dust explosion may leave much or little coked dust; and a firedamp explosion may produce coked dust that has played little part in the propagation of the explosion. One has to take into consideration the degree of probability of the presence of firedamp or of coal dust. In this case, while I see no likelihood of the presence of firedamp in these intake roads, I am entirely satisfied that there was enough inflammable dust to propagate an explosion.

*The Prevention of Coal Dust Explosions. Part I. The Effect of Manner of Distribution of Stone Dust by S. Jones and F. V. Tideswell, 1947.

Summary of Conclusions as to Cause and Development of the Explosion

Due to the thickness of the seam and to the fact that the roof caved in very large blocks, cavities of considerable volume existed behind the longwall face. As the waste was not ventilated, a large volume of firedamp slowly accumulated. When the roof weight, itself a consequence of the incompleteness of the caving, began during the night of 28-29th May, firedamp in the waste area was pushed nearer to the face and began to be emitted into the air current at roof level near the return end of the face. Roof fractures extending upwards led to influx of firedamp from the upper strata. At least to the point where disturbance was created by the air leaking through the stentons, the firedamp largely remained as a layer near the roof. Probably within half an hour before the explosion the emission was intensified. Falls in the waste caused surges of firedamp which would travel along the return as gradually dispersing concentrations.

Then, possibly not for the first time during the cutting operation, the cutter picks struck pyrites. The firedamp ignited by the consequent sparks may have been part of a surge from the waste. I think it more probable that it was firedamp released into the undercut as a result of the weight.

I believe that flame would emerge from the cut behind the machine and would alarm the machinemen who would naturally make for the adjacent roadhead without waiting to stop the machine. The flames, however, would lick towards the roof and there meet the under-surface of the flow from the waste.

The inflammation probably proceeded quietly to No. 28 stenton where its contact with a more inflammable mixture created explosive violence. The explosion passed backwards towards the face and forwards along the return, where it blew through to the intake at No. 26 stenton and at the extension of the West Belt Road. It continued along the return bursting southward at successive stentons to about No. 18 stenton. At No. 22 junction extra violence developed, possibly because the current then passing that point was highly inflammable. Thus into the lengths of the West Belt and Materials Roads between the Second South and Third South roads, where there were two double transfer points, flame came in two directions. I conclude that the explosion then became one of coal dust and that it spread as such, obtaining fuel mainly from the conveyors, the conveyor structures and the stentons.

The reason for its providential cessation on the West Main Level is uncertain. Dr. Tideswell suggested that it was checked because the outbye length of the fall on to this road had occurred before the flame reached that point. It may be, however, that as this was not a conveyor road but was in regular use as a haulage road, the coal dust and stone dust were more intimately mixed and therefore the stone dusting measures proved effective.

V.—COMMENTS ON THE CAUSE AND CIRCUMSTANCES OF THE EXPLOSION

Firedamp

(a) *Influence of the Method of Working*

The choice of the method of working the longwall face, by retreating, opening from a narrow heading, the roof in the waste being allowed to cave, was unfortunate.

If, as I believe, this led to the formation of large cavities in the waste in which firedamp accumulated and ultimately to the firedamp passing into the air current, it was a major cause of the disaster.

It is accepted mining practice that the beds overlying an area of goaf behind a longwall face shall be supported as soon as possible, either through packs or through heaps of caved debris.

For caving to be successful certain conditions must be fulfilled. As it is important that these conditions should be clearly understood, I repeat the quotation by Mr. T. A. Jones from the Second Report of the Durham Falls of Ground Advisory Committee :—

“ Conditions essential for the success of the caving method are that :—

- (1) the beds forming the roof for a certain distance above the seam must be of such a nature that they can be made to break off clearly and fall regularly, each cut, when the back supports are withdrawn behind the face ;
- (2) these beds must be of such a nature that they become fragmented as they fall and thus occupy considerably more space after they have fallen than they did in their original stratified condition ;
- (3) the beds which fall must be of sufficient thickness in relation to the thickness of the seam worked so that the natural packs formed by the fallen material will be fairly tight to the first strong bed above those which fall.”

Both the regularity and the height of the fall depend not only on the nature of the strata but also on the efficiency of the waste edge support. Although the chocks used on the face proved sufficiently strong, the wood props, which broke when the weights occurred, were unsuitable for the circumstances that developed.

It may be that, as Mr. Fry suggested, fragmentation would have improved as the face advanced and full abutment pressures were established, but it was agreed by all that the fragmentation had not been satisfactory up to the time of the disaster. Thus, the caving did not achieve its purpose, cavities developed and excessive stresses were imposed on the strata ahead of the face and on the supports (Diagram I).

Mr. Carter, discussing the importance of the roof support measures adopted in the early stages of a face advancing from the solid, pointed out the great transition that occurs, in a few weeks, from the conditions of a narrow heading in which there is often practically no strata movement, to those of a longwall face which is itself in a partly de-stressed zone but has a very high pressure zone ahead of it, a high pressure zone behind it, and the whole of the beds up to the surface in motion above it. During these vast alterations there are often periods in which the roof is easy to control but there is always a liability to sudden adjustments known as “ first weights ” and “ second weights ”. Experience has shown that it is not inevitable that these major changes of stress lead to dislocations at the face. Adequate supports will often counter their effects.

I therefore agree with the view expressed by Mr. Carter and Mr. Collins that strip packs should have been built in the initial stages, and cannot do better than quote what Mr. Collins said in evidence :—

" I feel very strongly that where a longwall face is moving off from the solid, whether it be an advancing face or a retreating face, initially strip packing should be applied. By that means the necessary time, with safety, would be afforded to study the actual roof conditions on that particular face without having to rely on conditions applying in other parts of the pit. Therefore, even though it is intended to practice the caving system I consider that it would be a desirable precaution to start the face with strip packing, gradually dropping out the packs as conditions show that the caving system was likely to be a success ".

The management believed that they had had experience in situations sufficiently comparable with that of the Third South to justify the adoption of the method practised, but they had not in this area opened a longwall face from a narrow heading and I do not think they realised the difference this made. I feel too that the roof troubles that occurred were not given enough attention. Had they been studied sufficiently, particularly during the shift in which the supports were advanced, that is the shift in which the effects of loss of roof control are most apparent, the occasional firing of shots in order to release the chocks would, I think, have been discovered, and this would have focussed attention on the need for a change in the method of working.

As a consequence of the incompleteness of the caving, considerable cavities must have existed in the goaf area. Because the face was retreating and had solid sides, there was not the ventilating pressure difference across the waste which, with leakage through the packs into the return, leads to the gradual release of firedamp from the waste of an advancing face. The emission of firedamp, although it was by no means rapid, would thus gradually fill the cavities to the point of overflowing, and the effect of the ventilating current would be, as shown in Diagram II, to conceal its existence.

Thus, while the retreating system, with or without caving, has advantages, the risks peculiar to these methods and the conditions in which it is permissible to employ them must be clearly understood and the proper safeguards observed.

To summarise my views on this aspect, I would say that unless the natural conditions are suitable and the support of the waste edge is effective, caving will not be successful, but will lead to heavy weights at the face and to large cavities being left in the waste. Particularly on retreating faces the cavities are likely to fill with firedamp, and when weights occur or the barometric pressure falls, it will be forced out into the air current. Caving should not, therefore, be practised unless the natural conditions and method of waste edge support are such that the roof in the waste falls regularly to a sufficient height and in a suitably fragmented state. In most cases strip packs should be built in the initial stages of a face opening out from a narrow heading ; they can be dropped gradually if and as the conditions developing as the face retreats show that caving is likely to be successful. On retreating faces, there being a greater liability to sharp increases in rate of firedamp emission, the quantity of air provided should be greater than that necessary on advancing faces in otherwise similar conditions. Investigations should be made to discover the extent of such variation in rate of emission.

Matters concerning the use of chocks call for brief comment. The firing of shots to release the chocks was a breach of the then existing rule in the Explosives in Coal Mines Order that, in mines where Permitted Explosives are required because of the possibility that inflammable gas may be present " . . . no shot should be fired in the roof of a longwall working between the coal face and the waste " without the written authority of the agent and the

manager. The firing of such shots is now prohibited in safety lamp mines by Article 35 of the new Order and relaxation can be granted only by the Chief Inspector of Mines or a Deputy Chief Inspector of Mines acting on his behalf. Several of the chock releases were found after the explosion to have tripped spontaneously and evidence was given that during a previous weight self-tripping had occurred. It was also said that sparks had been emitted when these releases had been operated under heavy load. The wide adoption of releases has enabled chocks to be built so as to resist roof movements effectively, and this has without doubt played a considerable part in the reduction in the frequency of accidents from falls of ground. Moreover, I appreciate that self-tripping of the releases is by no means common. It is nevertheless desirable that as forms of chock release free from this defect become available, they should be adopted.

The problem of the ignition of firedamp by frictional sparking is now the subject of active investigation by a Joint Committee of the Ministry and the National Coal Board. Meanwhile, in the present state of our knowledge it is necessary to avoid the possibility of sparking in the vicinity of firedamp, and where sparks are liable to be emitted on the release of chocks, or certain forms of prop, set at the waste edge, the releases should not be operated unless tests have been made with a flame safety lamp—particularly at the waste edge—and these have not revealed the presence of firedamp. I also urge the development and use of supports not liable to emit sparks on being released.

(b) Influence of the Ventilation

According to the statutory measurements the average quantity of air reaching the top of the intake drift to the Duckbill District was of the order of 23,000 cubic feet per minute. Let us consider what part of this was reaching the longwall face prior to the changes in the system of ventilation made within a few days of the explosion. It is a reasonable assumption that the normal flow exceeded the 3,200 cubic feet per minute found in the last measurements made before the explosion, on 16th May, for at that time the face was partly closed by a fall. I believe that it would amount to some 6,000 cubic feet per minute, which is the rough average of earlier measurements.

Although the normal yield of firedamp was low, accumulations of firedamp had been found in other parts of the district on several occasions. Often these were small, but a sudden large emission of firedamp from a fault side in the First South area was recorded. To quote Mr. Miron, the occurrence of firedamp “seems always to have been sporadic and unexpected”. Moreover, a point I have already considered, cavities were being formed behind the longwall face and were likely to be filling with firedamp which might be forced out at any time. I conclude, therefore, that though this volume of air was adequate to dilute the quantity of firedamp normally appearing in the air current, insufficient account was taken of the possibility, indeed one might say the probability, of temporary increases in the emission.

Was the quantity of air on the longwall face sufficient, judged by other standards? The cross-sectional area at the face was of the order of 70 square feet and, assuming a quantity of 6,000 cubic feet per minute, the velocity would be about 85 feet per minute.

Let me quote from the Third Report of the Research Committee of the Monmouthshire and South Wales Coalowners' Association entitled “A Study of the Physical Condition of Mine Air”—“The best conditions would appear

to exist when air velocities are between 150-450 feet per minute. These values are recommended for air having dry-bulb temperatures less than 75° F. Above 75° F. a higher range of air velocities is required in order to produce the necessary cooling effect". I appreciate that in thick seams compliance with these figures would require quantities of air greater than those usually provided, but, taking this considered opinion in conjunction with the evidence that sometimes the deputies in charge stopped the fan ventilating the headings and opened the adjacent door in order to clear shot firing fumes from the longwall face, I consider the volume of air passing along the face to have been below that required by good practice.

Shortly before the explosion a number of changes in the system were made—a fan was introduced for No. 24 heading, the fan feeding Nos. 21 and 22 headings, and the door associated with it, were removed from the Belt Road to No. 21 stenton, and on 27th May a second fan was installed in this stenton. Because the air taken by the fans passed direct from the headings into the return and was lost to the parent current, these changes must have substantially affected the quantity of air passing into the Third South face and it is to be regretted that the measures prescribed in the Coal Mines (Ventilation) General Regulations, 1947, that a determination of the firedamp content of the air current and a measurement of the quantity of air should be made as soon as practicable after the making of such alterations, were not observed. It is true that the interval between the last change and the occurrence of the explosion was short, but changes in ventilating arrangements may produce serious consequences quickly, and so when such changes are made, the position should be kept under observation until conditions have become stable again.

In the absence of such measurements of the air flow it is possible only to estimate very roughly an important figure—the quantity passing along the face at the time of the explosion. According to the statutory measurements, of the 23,000 cubic feet per minute already mentioned as reaching the top of the intake drift to the Duckbill District, rather more than 7,500 cubic feet per minute went to the Third West places and an average of some 6,000 cubic feet per minute to the First South places. There was available for the inbye end of the District—the Second South roads, with the two fans ventilating the heading ends, the longwall face and the three duckbill headings—some 9,000 cubic feet per minute. After 27th May, two and sometimes three auxiliary fans were drawing air away from the intakes to the duckbill headings. The fans were each of a type rated by the makers as being capable of deliveries of 3,400-4,000 cubic feet per minute with the lengths and diameter of tubing in use. The delivery tubes were said to be "snubbed", by means of cord tied round the tube, to restrict the flow. The last recorded measurements of the quantity delivered, on 21st May, showed that the single fan then ventilating Nos. 21 and 22 headings was passing 3,800 cubic feet per minute.

It is difficult to avoid the conclusion that at the time of the explosion the rate of air flow on the longwall face must have been well below the figure of 6,000 cubic feet per minute estimated to have been passing before the changes were made.

There is so much unavoidable uncertainty about the rate of emission of firedamp immediately prior to the explosion that it is not possible to say how a more ample supply of air would have affected subsequent events. It may be, however, that had the quantity been more in accordance with good practice, the firedamp explosion would not have extended far enough along the return to blow through into the First West intake roads.

Of the use of the auxiliary fans, Mr. Ronald Williams said in his closing speech :—

“ From the evidence there can be no question that the auxiliary fans were so situated that if they were running at the same time and to full capacity, they would exhaust the flow of air available at the face. Some attempt was made, I know, to reduce the pull of the fans by snubbing, but the mere fact that instructions were given to deal with this vitally important matter in this way is perhaps a more scathing comment on the ventilation methods employed than any words which I could use.”

These are severe strictures, but I am bound to agree that they are not unjustified.

As has already been said, with about 9,000 cubic feet per minute of air available, five auxiliary fans were installed on the intake side of the longwall face and three were so arranged that the air passing through them, after ventilating the headings, was delivered into the return. One of these three, it is true, only worked occasionally and all were regulated, but as the method of regulation consisted merely of a piece of cord tied round the air tubes, a burst air tube between the fan and the constriction or a chance blow which severed the cord, could have caused re-circulation or a partial short circuit.

Other unsatisfactory features were :—

- (a) The practice, adopted in respect of the fan supplying Nos. 21 and 22 headings when in its original position on the Belt Road and of the two fans in Second South, of placing a canvas door across the road at the point where the fan stood. An auxiliary fan as normally worked draws only a moderate proportion—Professor Statham* recommends not more than 25 per cent.—of the air passing along the airway from which it takes its supply, the remainder passing on unimpeded. Though it is true that there were alternative paths for air to reach the longwall face, the doors placed at these fans constituted restrictions which, in my view, were undesirable.
- (b) The stopping of fans ventilating places in which firedamp was liable to accumulate. Evidence was given of an occasion in Second South when, following the stoppage of the fans and the opening of the doors, firedamp accumulated in the headings. Obviously when the fans were restarted the gas must have been carried on to the longwall face.

In some cases auxiliary fans should be kept running permanently in order to comply with Section 29 of the Coal Mines Act, 1911, which requires that “ an adequate amount of ventilation shall be constantly produced in every mine to dilute and render harmless inflammable and noxious gases to such an extent that all shafts, roads, levels, stables and workings of the mine shall be in a fit state for working and passing therein ”. If, for any reason, such fans have to be stopped, there should be alternative arrangements providing a sufficient flow to prevent the accumulation of noxious or inflammable gas, even when work is not proceeding in the place concerned.

Generally, however, the starting and stopping of fans is to be deprecated as the resulting redistribution of ventilating pressure may produce effects over a considerable area.

*Transactions of the Institution of Mining Engineers, vol. CIII, page 348.

I think the reason for these makeshift methods is to be found in Mr. Jones' examination of the Assistant Agent, Mr. H. E. Morgan :—

“ Q. When this longwall face was won out, did you consider or discuss with anyone the question of the ventilation of the ventilating district inbye of First South ?

A. No, I do not think it was discussed individually.

Q. Did you realise that the opening of Third South face would make a considerable change in that ventilating district ?

A. That was overlooked, I think.

Q. It was overlooked ?

A. Definitely overlooked.”

No. 14 (5) of the Coal Mines (Ventilation) General Regulations, 1947, lays down that “ in respect of any section of narrow or panel workings the ventilation of which involves the use of two or more auxiliary fans drawing air from the same air current, a plan shall be prepared showing the general system of ventilation and the directions and quantities of the air currents ; and a copy thereof, and of any subsequent plan showing any change in that system, shall be delivered as soon as practicable to the Inspector of the Division ”. No such plan was sent to the Inspector following the opening of the Third South and the manager, in answer to Mr. Jones, said that he “ did not consider it a change ”.

Whatever the legal position may be, there can be little doubt that had a plan even been prepared the potential danger in the arrangements would not have been overlooked.

I recommend that all existing systems of ventilation employing multiple fans should be reviewed and new systems studied to ensure that :—

- (i) the volume of air is large enough not only to avoid the possibility of re-circulation in any place ventilated by an auxiliary fan, but also to provide for the adequate ventilation of all other working places ;
- (ii) no fan is stopped unless there is alternative means of providing adequate ventilation ;
- (iii) if it is necessary to regulate a fan, it shall be done in such a way as to prevent unauthorised or inadvertent alteration.

(c) Ignition by Frictional Heating or Sparking

It was clearly established by the evidence that sparks were produced by coal cutter picks in various parts of the Duckbill District. Most of the witnesses, it is true, referred to sparks produced in the headings by shortwall machines when jibbing in and unfortunately the men best qualified to speak of conditions on the longwall face were killed in the explosion. One of the mechanics, however, said that he had seen sparks in the undercut on this face and I see no reason to suppose that it was any different from other parts of the district in this respect.

It has, of course, been known for many years that firedamp could be ignited by the action of coal cutter picks on pyrites and on certain types of rock or inclusions containing quartz. I have purposely avoided using the word “ sparks ” because with pyrites at least it would seem that ignition is not caused by the sparks themselves so much as by finely powdered pyrites dust which is heated by friction until it bursts into flame. This distinction in the mechanism

of ignition is important because it accounts for the fact that blunt picks are more likely to cause ignition than sharp ones.

Many of the men in the Duckbill District had seen sparking often and, as nothing untoward had occurred, they may have formed the impression that it was not dangerous. Indeed, as Mr. Miron said, some such impression appears to exist amongst mining people as a whole. But an analysis of all reported cases of ignitions of firedamp from 1937 to 1951 has shown that, excluding ignitions from naked lights, coal cutter picks are second only to explosives as an igniting medium, 91 ignitions have been caused by cutter picks and 100 by explosives. It has not been possible to establish the number of cases in which pyrites was involved, but there is no doubt that they were many.

Attempts have been made to reduce the risk by introducing an inhibitor into the cut. Wet cutting, especially if the water passes through the jib so as to wet the picks as they are entering their cutting path, must have a suppressing and cooling effect, but it is not possible to say that it would always prevent ignitions. Carbon dioxide has been tried, but it is not easily practicable to provide the volume necessary. Atomisers have been used, as Professor Poole stated in evidence, referring in particular to the successful results obtained with them by Mr. R. D. Beilby*. However, not enough is known about the incidence of firedamp in the cut, though we do know that it may vary most widely in place and time on the same face, and there is much more to be learned of the action of suppressors. Following a recommendation by the Safety in Mines Research (Advisory) Board, a Working Party consisting of members of the Ministry of Fuel and Power and of the National Coal Board has been formed to investigate the problem. As hazards of ignition from friction are not confined to coal cutters, the terms of reference are :—

“ To review the risk of firedamp ignitions by frictional sparking or frictional heating arising out of underground coalmining operations, with particular reference to coal cutters and stowing machines ; to recommend what lines of investigation should be followed ; and to advise as expeditiously as possible on the steps which might be taken to remove or control this risk ”.

Pending the findings of the Working Party the following precautions should be taken :—

- (i) Wherever coal cutters are in use or are to be used, a survey should be made for the purpose of selecting a cutting horizon, as far as is practicable, clear of any material from which sparks may be struck.
- (ii) The general policy in gassy seams with no clear horizon should be to adopt one of the alternatives to cutting, or to adopt measures such as stowage or draining of the wastes to prevent accumulation of firedamp at the waste edge.
- (iii) Every effort should be made to ensure that only sharp picks are used.
- (iv) Water hose with an ample supply of water should be provided within easy reach.
- (v) Having regard to the dust and sparking problems, it should be the general policy to avoid dry cutting.

(d) Firedamp Detectors

The Coal Mines General Regulations (Firedamp Detectors), 1939, require that firedamp detectors shall be provided at certain places and for certain men.

*Transactions of the Institution of Mining Engineers, 1941, vol. C, page 212.

In compliance with these Regulations the coal cutter men on the Third South face were provided with a detector in the form of a flame safety lamp. One of the other men working on the face at the time had also been supplied with a flame safety lamp although this was not required by the Regulations. Neither of these lamps was at the face when the explosion happened, both of them having been left in the intake.

It is impossible to say whether the firedamp would have been detected in time if the lamps had been at the face, but the chance that it might have been was lost when they were left in the gate road.

By and large, detectors are issued only to men working in places where firedamp may be a hazard ; if they are to be of any real value they should be kept constantly within sight. For this reason the Regulations prescribe that a man who is provided with a flame safety lamp as a detector shall not have any other light, except with the written permission of the manager. This permission is, however, usually given to men such as coal cutter operators who need a good light and the use of both hands. The detector lamp is then just one more thing to carry and—human nature being what it is—it is the first thing likely to be jettisoned. Confirmation of this, striking in its simplicity, came from one of the witnesses—a duckbill operator—who with an admirable absence of equivocation said that if he had a lot to carry he sometimes left his safety lamp behind because it was the thing most easily dispensed with. Evidence given by the lamp-man showed that the duckbill operator was not alone in these views, and I am afraid that they are not confined to Easington nor to any one coalfield.

The function of a firedamp detector is to give timely warning of the presence of firedamp. If it is left behind because it is a cumbersome extra for a heavily laden man, it will give no warning to anybody of anything. Properly used in the proper place it may be the means of saving many lives. It gives a chance and it is tragic if that chance is thrown away. Both men and officials have a duty to see that it is not thrown away and I appeal to the National Coal Board and the National Union of Mineworkers to do everything in their power to ensure that that duty is discharged.

At the same time I recommend that research should be undertaken to develop a combined cap lamp and detector. Accuracy within fine limits is not necessary, but it must be reliable, easy to wear and give a good light. Also I endorse the view of Mr. Robert Yates, H.M. Deputy Chief Inspector of Mines, in his report on the explosion at Eppleton Colliery, that there is need for a device which would automatically cut off the electric power in an atmosphere containing a pre-determined percentage of firedamp.

Coal Dust

In view of the conclusion that the spread of the explosion was caused by coal dust, it is necessary to review the measures taken to meet the requirements of the General Regulations (Precautions against Coal Dust) 1939.

(a) *Method of Sampling*

All the sampling in the North Pit was done by one man. His method was to start at the outbye end of the district and to collect samples from the roof, floor and sides respectively of each consecutive length or zone of roadway whether the road was one used for the transport of coal, a materials road or an airway. As his monthly quota of samples for the Duckbill District was 72, the maximum number of zones from which he could take samples was 24, and

as each zone was 176 yards long and as he continued to sample the same zones month after month, only a little over 4,200 yards of the 16,000 yards of roadway estimated to have been traversed by the flame had been sampled within the period of six months covered by the evidence.

The Regulations require that all accessible roads must be systematically sampled. On roads used for the transport of coal and in return airways within 200 yards of the face, it is laid down that the number of samples collected monthly shall not be fewer than in the proportion of ten per mile, except with the consent in writing of the Inspector or unless the natural conditions ensure compliance with the Regulations. For other roads the requirements are less specific, but as it is provided that a road may be sampled at intervals not exceeding three months if it has been shown that the application of stone dust is not required more than once in six months, the inference is that without such evidence the intervals should be considerably less than three months.

It is also laid down that "if since a sample was last collected over such a section of road, some part of that section has been treated with incombustible dust more frequently or more recently than other parts, separate samples shall be collected over the several parts irrespective of their lengths". This clearly indicates that in the vicinity of transfer and loading points, where, according to the evidence, stone dusting was done much more frequently than elsewhere, samples should have been taken over lengths shorter than 50 yards.

Sampling in itself cannot, of course, make a pit safe—it is only a means to an end—but it is an essential part of any system of dust control. It is disturbing therefore to find that it was carried out with so little understanding and that roads could remain unsampled for so long without the higher officials becoming aware of it. The sampler said in evidence, and it was not refuted, that he had continued the method of sampling used by his predecessor, the only person from whom he had received any instruction in his duties. He admitted that he had never drawn attention to the fact that parts of the roadways were not being sampled; on the other hand, his superiors seem to have concerned themselves only with observing whether the incombustible contents of the samples taken were within the proper limits.

(b) Suppression, Removal and Treatment

For the suppression of dust the management relied on the use of water sprays at the transfer points—wet cutting and water infusion having been abandoned after short trials. Sprays when used in conjunction with some form of enclosure so designed that the dust is driven on to smooth surfaces to which it adheres, and from which it is subsequently collected in such a way as to prevent its escape into the air, are effective. With sprays used as at Easington the wet dust particles settle on the roof, floor and sides and subsequently dry out.

Evidence was given that on the stone-shift from eight to ten men were wholly engaged in cleaning up spillage and stone dusting, and up to 18 men were so employed for part of the shift. In addition there was a man on the fore-shift who cleaned up and stone dusted the trays of the conveyors. It is right and proper that spillage should be cleaned up, but the amount of spillage must have been excessive to necessitate the employment of so many men and more attention should have been given to its prevention. The spillage was loaded on to the belts and thence into tubs and, though it was wetted, a great deal of dust would be raised into the air during both operations; some would stick to the belts and, as it dried out, would be deposited over the whole length of the conveyor structure.

The local application of stone dust at transfer and loader points was carried out by the men who cleaned up spillage. There was also a man on the back-shift who stone dusted the roads near the face. What was described as the strategic stone dusting of the mine was carried out by a team of seven men under a leader known as the stone dust man. According to this man it took three to four weeks to stone dust the Duckbill District and it was re-treated about every four weeks. It is difficult to reconcile this with the needs of other parts of the mine, but as no written records were kept the position remains obscure. He admitted, however, that no stone dusting had been done in the Third West since it was finished and that he left the stone dusting in the Main Coal Training District to the people in charge of training.

There was, however, evidence which I accept, that beginning on the 16th April, the intake roads in Third South were stone dusted right up to the face and that the Third South Return between the face and the First West Materials Road was treated during the week before the explosion. Indeed, most of the team were still engaged in the District and were killed in the explosion.

Although he kept in touch with the sampler and re-treated any zone from which an adverse sample had been taken, the stone dust man otherwise used his own judgment as to where and what treatment was required.

(c) General

Almost haphazard as the sampling and stone dusting may have been, it must be noted that the incombustible contents of the samples taken before the explosion were well above that required by statute, and it may be that had samples been taken in other lengths of road which had been stone dusted in the same way, similar results would have been obtained. The results of the samples taken after the explosion by Mr. Badger tend to confirm this view. Excluding the Main Coal Training Area where, as I have already mentioned, the treatment was left to those in charge of training, 113 out of 135 samples contained more than 75 per cent. of incombustible matter, and Mr. Collins quite properly pointed out that the average incombustible content, including the samples from the Training Gallery, was 75 per cent.

Mr. Badger's samples were taken in the manner prescribed in the Regulations and, as was pointed out in the Inquiry into the explosion at Valleyfield Colliery in 1939,* samples taken in this way do, viewed as a whole, give a rough guide to the general composition of the road dust as determined in a similar way before the explosion. Moreover, in explosions in which the stone dust and the coal dust have been intimately mixed the composition of the dust, as determined by such samples, has not differed greatly from the composition of special samples taken to include as far as possible only dust which had been in the explosion cloud. The wide difference in the results of the two types of samples in this explosion—it will be remembered that Dr. Tideswell gave the incombustible content of a large majority of the samples of the explosion dust as between 30 per cent. and 55 per cent.—is quite consistent with the theory that the explosion was propagated on its main path by coal-rich dust from transfer points, from the structure of the conveyors, from the belts, including any coal in transit, and to some extent from the stentons.

Before I continue with this main problem—coal dust in conveyor roads—I should deal with the spread of the explosion off its main path.

*Report on the Causes of, and Circumstances attending, the Explosion which occurred on the 28th October, 1939, at Valleyfield Colliery, Culross, Fife. Cmd. 6226.

The spread of the explosion off its main path to the faces of the Straight North and Third West places and elsewhere was mainly due to coal dust picked up from disused roadways. Such roads, unless they are sealed off, tend slowly to accumulate airborne dust and if they are driven, as these roads were, in the seam, they accumulate coal dust through spalling of the sides.

Mr. Robert Yates, H.M. Deputy Chief Inspector of Mines, found that coal dust deposited in disused roads contributed to the explosions at Murton* and Louisa† Collieries. As Mr. Yates said, if and so long as such roads are accessible they should be treated fully in accordance with the Regulations. Otherwise they should be sealed off permanently or special measures of protection should be arranged at the mouths of any inaccessible places—for instance by shelf barriers or an arrangement of walls with a sandwich of stone dust. Clearly, the existence of passages in which fine coal dust may accumulate and which are open to any explosion that may occur in the workings defeats care taken in maintaining the working roads in satisfactory condition. This matter is of particular significance in County Durham where, as Mr. Yates pointed out, disused roads abound in bord and pillar mining.

The sources of the coal dust in the main path of the explosion were mainly peculiar to conveyor roadways. Attention was drawn to the importance of this problem in the Report‡ of the Royal Commission on Safety in Coal Mines published in 1938. The Commissioners foresaw that the importance of the problem would grow as the use of conveyors became more extensive. Tragic confirmation of this view has been afforded by this explosion and those which occurred at Whitehaven William and Louisa Collieries in 1947. Additionally, the numbers of fires which have been caused by conveyors, culminating in the disaster at Creswell Colliery in 1950, leave no doubt about the degree of risk attending their use.

The time has come to take stock of the position.

(d) What can be done?

Transport by road conveyors has its advantages, but there is reason to believe that there is an optimum length beyond which the method becomes uneconomic. I was, moreover, surprised to find at Easington that there were so many men engaged primarily on cleaning spillage. The installation and maintenance costs of the additional safeguards against fire and explosion, which bitter experience has shown to be essential, will not I think be light. Thus it may well be that in many instances the economic advantages of road conveyors will disappear entirely. I have no doubt that all these matters will be subject to fresh review by the National Coal Board and it is possible that the use of long roadway conveyors may tend to decrease, but even so the hazard would diminish only gradually over a considerable number of years and a more immediate remedy must be sought.

The Royal Commission proposed that a Joint Committee should be set up by the then Mines Department to work out appropriate methods of dust prevention and collection on conveyor roads. Such a Committee was appointed and did some preliminary work but, owing to the outbreak of war, it was allowed to lapse. In the meantime these problems have received a good

*Report on the Causes of, and Circumstances attending, the Explosion which occurred on the 26th June, 1942, at the Murton Colliery, Durham. Cmd. 6413.

†Report on the Causes of, and Circumstances attending, the Explosion which occurred at Louisa (including Morrison Old) Colliery, Durham, on the 22nd August, 1947. Cmd. 7374.

‡Report of the Royal Commission on Safety in Coal Mines, 1938. Cmd. 5890.

deal of attention. Particularly as a result of the work carried out to limit airborne dust because of its effect on health, there has been a realisation that effective dust prevention and suppression at the working face can reduce the rate of dust deposition on conveyor roadways. But the problems are by no means solved and I therefore revive the Royal Commission's suggestion in a somewhat amended form by recommending that a Committee should be appointed, representing the various interests, to investigate the use of roadway conveyors with a view to determining the limits within which they may be safely and advantageously employed.

In the meantime everything possible should be done to accelerate progress in the direction of preventing the formation of dust, and of suppressing such dust as is unavoidably produced, as close to the point of production as is practicable.

The progress should, of course, start at the coal face by such measures as improved roof control; by a reduction in shot firing; and, where appropriate, by water infusion and by wet cutting, supplemented with spraying where necessary.

The conventional type of coal cutter, in addition to its liability to produce dangerous sparks, a matter with which I have dealt, is by its design a maker of dust. At present there is no universally practicable alternative to its use, but there are a number of promising lines of investigation. One of these arises from the fact that in some places where water infusion has been adopted, the coal has been found to work so much more easily that the use of coal cutters has been discarded. So far it has been considered possible to adopt water infusion only where the natural conditions have been particularly favourable, but I believe that the technique can be developed so as greatly to increase the range of these conditions. For example, seams which cannot be infused by a steady hydraulic pressure might behave quite differently if a shock wave could be sent through the water column. Another possibility is the development of machines operated by slow moving forces as, for instance, the coal plough. Here again existing machines of this type have had only a limited success in this country, but it should not be beyond the wit of man to overcome their limitations.

I therefore recommend that investigation should be undertaken (a) with a view to extending the range of applicability of water infusion and to developing its possibilities for working coal, and (b) to hasten the development of coal getting and loading machines operated by slow moving forces.

During transport, dust is both produced and released into the air wherever the coal falls freely. Every practicable measure should therefore be taken to eliminate spillage and to reduce to the minimum the height of the free fall in the transfer of the coal from conveyor to conveyor or from conveyor to tub. Both can be reduced by the use of properly designed chutes. Far too often conveyors deliver on to other conveyors moving at right angles without any provision to bring about a smooth change in the direction of motion of the coal. And here I would call attention to a most useful paper by Mr. J. V. Spence, one of H.M. Inspectors of Mines.*

Some spillage at loading points may be unavoidable and arrangements should therefore be made for it to fall into hoppers containing water or fitted with sprays, from which it may be subsequently loaded out without releasing dust into the air. Provision should also be made to clean and collect the dust from the surface of the return belt.

*Transactions of the Institution of Mining Engineers, 1951, vol. CX, page 313.

Even where these precautions have been taken, it may still be necessary to make provision for the suppression of dust raised into the air at transfer and loading points. As I have already mentioned, sprays are not effective unless steps are taken to confine and collect the wetted dust particles. Complete enclosure is not essential. All that is required is that the dust particles shall be driven on to surfaces to which they will adhere and from which they can subsequently be collected.

Measures based on these general principles will, if thoroughly carried out, effect a material reduction in the quantity of dust deposited on the roof, floor and sides of roadways. They will not, however, prevent it entirely and it remains to consider further measures to deal with the residue. The need for regular and thorough cleaning and for the application of stone dust on the "little and often" principle is well known. Attention should, however, be given to the way in which the cleaning is done—shovelling dust and spillage on to a conveyor belt or into tubs merely results in moving the finer and more dangerous dust from one place to another. Experiments with a form of vacuum cleaner originated jointly by the National Coal Board and H.M. Inspectors will, if successful, go a long way towards a solution of this problem. In the meantime, when cleaning is being done, the dust and small spillage should be well wetted and loaded carefully into bags for transport to the surface. Needless to say, when a place has been cleaned it should be re-stone dusted immediately.

As has already been pointed out, one of the factors tending to increase the dust hazard on conveyor roads is that the stone dust and the coal dust are not intimately mixed. The "little and often" principle attempts to overcome this but even if stone dusting is done several times during a working shift, it does not produce a really intimate mixture of coal and stone dust. To some extent at least this could be overcome by a device which puffs out small quantities of stone dust automatically throughout the shift. This is not a new idea but it has never found favour because it may cause discomfort and inconvenience to workers by increasing the total amount of dust in the air. If, however, the amount of coal dust is kept down to the practicable minimum the quantity of stone dust needed would not be excessive. In any event it is a method which might be worth a trial at transfer and loading points.

When all these measures have been taken there will still remain the problem created by the ease with which coal dust can be raised by the blast of an explosion from the conveyor structure and from the belts. The only practicable solution at present in sight seems to be the provision of some form of dust or water barrier at suitably chosen sites. There is still much to learn about barriers, but experience in Germany with dust barriers of the shelf type has been sufficiently favourable to justify their adoption in this country until something better is devised. Research should be carried out in the further use of dust barriers and in the development of water barriers, and in the meantime shelf type barriers should be installed on conveyor roads.

As regards sampling, I have already pointed out that the present statutory procedure was designed to show the average composition of the dust. On travelling and rope haulage roads, where the dust on the floor is mixed and raised by the passage of traffic, the composition as so determined would not in general differ greatly from the composition of the dust cloud raised by an explosion, and the prescribed standards of incombustible matter provide a reasonable safeguard against continued propagation. It is clear, however, that these results are not achieved in the very different circumstances produced by conveyor transport. Unfortunately, until more is known about the rate of deposition of coal dust at different places and under differing conditions, it is impossible

to prescribe either appropriate standards or methods of sampling by which to ascertain whether they are being observed. I recommend therefore that (a) tests should be made under actual working conditions to determine the rate of dust deposition primarily but not solely on conveyor roadways, and (b) experiments should be carried out for the purpose of evolving an improved sampling technique.

Here it seems appropriate to say that no sampling procedure can be effective unless the object is clearly understood and the method is applied conscientiously and with intelligence. It was probably with something of this in mind that Professor Poole suggested in evidence that sampling should be "placed completely in the hands of the scientific staff of the National Coal Board". I am in sympathy with the idea behind this suggestion, but if it were carried out it seems to me that it might create a situation similar to that which led the Lord Justice General, in his judgment on the appeal of the Crown in the Knockshinnoch Castle Colliery proceedings, to say "What was everybody's business was nobody's business". The scientific staff would not be responsible in law and the manager could not be held responsible in justice. This is, of course, an instance of the general problem—the problem of the responsibility of specialists in the industry. Fortunately there is, I think, a solution in this particular case which in no way encroaches on the responsibility of the manager. Merely as a matter of common prudence colliery managements should consult the scientific staff about the organisation of their sampling and stone dusting arrangements. Colliery dust samplers and men in charge of stone dusting should be given a course of training under the supervision of the scientific staff and should work as a team and to a plan under responsible supervision. From time to time the management should call on the scientific service to make check surveys and to advise on precautions desirable at special points. In addition, as frequent sampling and quick results are vastly more important than high degrees of accuracy, the assessment of samples should be speeded up by the more widespread introduction of optical methods. I recommend accordingly.

What must be exercising the minds of many who read this Report is the fact that in spite of the labour expended on cleaning up coal dust and laying stone dust, and although the sampling done before the disaster showed the presence of high percentages of incombustible matter, yet, according to the findings, a coal dust explosion occurred. Though they may accept the criticism of the way in which the operations were performed, they may nevertheless feel a loss of confidence in stone dusting and cleaning up as safeguards. That more must be done I have already said, but I trust that nobody will think that these measures are valueless. They have stopped the spread of a number of explosions and though many good lives were lost at Easington, if the roads had not been stone dusted the explosion might have acquired such violence that it would have spread far beyond its actual confines and caused one of the greatest disasters in mining history.

Casualties to Rescue Workers

John Young Wallace, a fully trained rescue man of 26 and an overman at Easington, was acting as the captain of a rescue team when he met his death. About half an hour after leaving the fresh air base the team was exploring the West Materials Road in the neighbourhood of No. 10 stenton when, without any previous signal of distress, Wallace sank to his knees, said a few words from the side of his mouth about sweating, sat down and then fell over unconscious. Probably he died almost at once as his jaw would sag when he lost consciousness and the lethal external atmosphere leaking past the mouth piece would prove fatal within a few moments.

Apparently the team had been walking rather more quickly than is usual or prudent in rescue operations and they had had to negotiate a number of obstructions, but they had travelled only about 700 yards from the base and no other member of the team was distressed.

According to the evidence, when Wallace collapsed his mouth-piece and nose clip were in place ; air was flowing normally into the breathing bag from the liquid air pack ; and he had not previously spoken.

Subsequently the Ministry's Rescue Apparatus Testing Officer, Mr. J W. Calder, one of H.M. Senior District Inspectors of Mines, examined and tested the apparatus in the manner prescribed for the approval of rescue apparatus and found it to be in order.

Nevertheless, Wallace undoubtedly died from carbon monoxide poisoning and it is therefore necessary to try to find how it got into his system. Post-mortem examination revealed in both lungs a degree of emphysema sufficient to cause breathlessness on heavy physical exertion, especially if such exertion were undertaken whilst wearing self-contained breathing apparatus under conditions of both mental and physical stress. In answer to questions by Mr. T. A. Jones and myself, Dr. W. C. Sharp, H.M. Medical Inspector of Mines, expressed the opinion that as a consequence of his exertions Wallace might have experienced sufficient difficulty in breathing to cause an involuntary opening of the mouth ; that this would allow the outside atmosphere to leak past the mouth-piece ; and that with the high concentration of carbon monoxide existing—probably of the order of three per cent.—even a slight leakage would induce a sufficient quantity into the breathing circuit to cause him to collapse.

This appears to be the most likely explanation of what happened.

Three days after the death of Wallace, H. Burdess, a trained rescue man, died in somewhat similar circumstances.

About 35 minutes after leaving the fresh air base, Burdess signalled to his captain that he was in distress. His breathing bag was inflated and functioning normally and his nose-clip and mouth-piece were in place. Although the team had only travelled between 600-700 yards and the other members were quite cool and comfortable, he was sweating heavily. His captain and another man tried to help him out but after going ten to 12 yards he collapsed. Eventually he was carried out on a stretcher, but on arrival at the fresh air base was found to be dead.

Examination and tests of the apparatus carried out by Mr. Calder showed that the automatic relief valve was set at 2.6 inches water-gauge instead of 3.5 inches water-gauge, and that one of the teeth grips of the mouth-piece was torn. Otherwise the apparatus was in order.

The effect of the relief valve being set at 2.6 inches water-gauge would be to bring down the volume of air in the breathing bag to rather less than the six litres normally held when the valve is set at 3.5 inches. This, however, should not have had any adverse effect as the quantity of air produced by the Aerophor apparatus is much in excess of that normally required ; to quote Mr. Calder, "I would not expect it to affect a man's breathing in any way other than to reduce the resistance against breathing". As regards the torn teeth grip, it is impossible to say when the damage took place. It may have happened before or after Burdess collapsed, but in any event I do not think it had any particular significance. This view was confirmed in part at least when the apparatus, re-charged but otherwise as it was taken from Burdess' body, successfully passed one test in which the wearer walked for two hours at four

miles per hour and a second test of two hours in which various operations were carried out in an irrespirable atmosphere.

Thus again the question arises as to how the carbon monoxide was inhaled and once more I think the explanation is provided by the post-mortem evidence. A condition known as bullous emphysema (distension of air sacs to blister like formations on the surface of the lungs) was found at the post-mortem examination. One bulla, or blister, on the left lung had ruptured, permitting air from within the lung to pass into the chest cavity and so causing a partial collapse of the lung. Dr. Sharp explained that when the bulla burst it would produce "reasonably acute pain" accompanied by violent efforts to breathe and that, as with Wallace, leakage of air past the mouth-piece might then occur.

If these explanations of the way in which these two men met their deaths are correct—as I believe they are—the question arises as to whether the physical defects from which they were suffering could or should have been discovered.

Under the Coal Mines General Regulations (Rescue) 1928 rescue workers (a) are examined every 12 months by a qualified medical practitioner in accordance with specified rules, and (b) when engaged in actual rescue operations are examined by a qualified medical practitioner before undertaking a second spell of work. No rules are laid down for the way in which the latter examination shall be carried out.

I understand that the degree of emphysema found post-mortem in Wallace's lungs would have been extremely difficult to detect during life by ordinary examination methods, and it is, of course, possible that the condition had developed in the interval between the time of his last annual examination and the date of his death. It is unlikely that it would have been detected in the course of the less exhaustive medical examination that it is possible to make during emergency operations. Wallace was a member of one of the earlier rescue teams and he was not medically examined before going on the spell of duty that ended in his death. Later, arrangements were made for the medical examination of all rescue men, whether on their first or subsequent spells. This practice should be made general forthwith. In the early stages of a disaster when minutes may make the difference between saving and losing lives, it would of course be quite wrong to hold back rescue workers until they are medically examined. As soon as conditions permit, however, they should be medically examined before they undertake any duty requiring the use of apparatus, as was done at Easington. Furthermore, I recommend that they should be examined medically at six-monthly intervals and that the most careful inquiry should be made regarding any illness which may have occurred between one examination and another.

The case of Burdess is somewhat similar except that he was medically examined before starting on the spell of duty—his first—during which he died. This serves to emphasise the difficulty in diagnosing a moderate degree of emphysema by ordinary routine examination. Mine rescue work imposes both mental and physical strain upon those engaged in it and it is desirable, therefore, that the requirements regarding the medical examination of rescue workers should be reviewed in order to ensure that only those attaining a high degree of fitness are selected.

Although there is no reason to suppose that it had any bearing on his death, it was brought out in the evidence that Burdess had been at the colliery for about eleven hours. It is true that suitable provisions were made for the comfort of the men who were standing by, but I suggest that wherever possible they should be allowed to remain at home on call until they are needed.

I sincerely trust that the deaths of these two men and any comments which I may have made will not impair confidence in existing rescue apparatus. It is true that the two main types of apparatus now in general use can be improved ; for example, they can be reduced in weight and it should be possible to evolve a better form of mouth-piece or a mask. I am glad to be able to say that measures have already been taken by the Ministry and the National Coal Board to ensure that these and other improvements are effected and that new types are developed. Let there be no mistake however—rescue apparatus in its existing form has stood the test of time and has enabled magnificent work to be accomplished with remarkably few failures. Given a proper understanding of its limitations, attention to detail and strict discipline, it will still do so.

Management of the Colliery

The Inquiry brought to light a number of bad practices and even direct contraventions of the Act and Regulations not causally connected with the explosion. They must nevertheless be considered in forming an opinion of the way in which the colliery was managed.

It was admitted that the provisions of the Explosives in Coal Mines Order were not complied with in that some at least of the deputies had not been instructed as to the maximum number of shots they were permitted to fire in any one hour or any one shift. Moreover, no tests had been made since 1948 to determine the time required to fire a shot.

The same Order was contravened in spirit at least by the practice of allowing the deputies to take into the mine more detonators than they required for use in their own districts in order that they could fire shots in other districts.

After the disaster 11 pounds of explosives were found buried under dirt in No. 21 heading. It must have taken some time for such a quantity to be accumulated and, evidently, not only was there a breach of the provision of the Order requiring that any explosive unused at the end of a shift should be brought out of the mine, but also the methods of control must have been woefully defective.

Evidence was given by two deputies that they had neither been given a copy of the Explosives in Coal Mines Order, 1948, nor had they been informed of the prohibition of the firing of shots in the roof at a longwall face other than with the permission in writing of the agent and manager. As I have already mentioned, there was evidence that on several occasions shots had been fired in the roof at the face for the purpose of releasing very tight chocks. The agent and manager denied any knowledge of the practice. The under-manager said that it came to his notice only the day before the explosion and that he immediately gave orders for it to cease. Although I accept the word of these officials, the fact that this method of releasing tight chocks remained undetected is a reflection on the value of the supervision exercised.

As regards matters other than shot firing, there was evidence that auxiliary fans had been started by unauthorised persons contrary to the requirements of the Coal Mines (Ventilation) General Regulations, 1947 ; the stoppings between the main intake and return airways in the Duckbill District did not conform with the requirements of General Regulation 91 ; a man in charge of an electric drilling machine had not been provided with a firedamp detector as required by the Regulations ; and on one occasion electrical apparatus which had been removed and re-erected in a new position had not been tested.

Singly some of these matters might not be of great moment. Collectively and taken in conjunction with unsatisfactory features discussed in earlier parts of this Report, they indicate a disquieting lack of control and direction.

In his closing address Mr. Ronald Williams said, " We have or had a situation prior to the explosion completely inconsistent with good management ". Mr. Williams made it clear that he was not referring to a particular individual but to all who were responsible for the management side of the colliery, and later added, " I cast no doubts about the sincerity and good intentions of the men concerned, but I do say that in the organisation at the managerial level at this colliery there were grave defects which have been shown in the evidence—and these defects are very closely related to the causes of this explosion ".

This is a not unjust summing up.

The officials who gave evidence impressed me as being hard working and conscientious men but they seemed to lack that ability to anticipate events and that comprehensive knowledge of what was happening at the colliery which is characteristic of good management. In the main this seemed to me to be due to weaknesses in the organisation. The manager appeared to be so fully occupied himself in day to day details of administration that he was unable to exercise effective supervision and direction of the mine as a whole. Still less had he time to think out all the possible consequences of a major change of policy such as the decision to adopt longwall retreating with full caving in a district originally planned to be worked by other methods.

Because of their duties in connection with the two other large mines in the group under their charge, the activities of the agent and his assistant were too widely dispersed to permit of their giving any effective help and guidance to the manager or, indeed, to allow them to gain the close knowledge of the conditions at the colliery which would have enabled them to do so.

In short, nobody seemed to be in a position either to see the situation as a whole or to think it out if he did.

It is not within my province to deal with the managerial organisation in general, but, in so far as I believe it to have a bearing on the disaster, it seems to me that in this particular instance there were good grounds for the appointment of a full time agent.

On the planning of the Duckbill District there was evidence that full use was made of the specialist consultant services and that, before it was decided to adopt longwall retreating, consultation took place right up to Divisional level. I am, however, left in some doubt about the value of consultations which did not make provision for the particular difficulties in roof control likely to be encountered when opening out on the caving system from a narrow heading in a virgin area, and which overlooked the ventilation problem resulting from the change.

In his submission on this subject, Mr. Miron said, " It seems clear that in this case, when the decision was first taken in 1947 to plan this entire district as a duckbill district, there was adequate consultation and avail made of those services at Divisional level. Subsequently the what I might call detailed day to day operations in the development of particular faces and changes of work at different points must be left to those on the spot, and it would not be good organisation to do otherwise.

I hope from my questioning of Mr. Fry I made clear to you, Sir, the position of the Area General Manager. He is in effect the Chairman or the Managing Director of his Area, and he is responsible for the co-ordination of all the Area activities. In the same way as at Divisional level so are there available

to him a certain number of specialist or consultant advisers. I would ask you to accept on that point that the organisation of the planning of this work was adequately carried out, that the subsequent development of the district and the working of this face was undertaken by those whose duty it was to do such work without reference to other people ”.

I cannot accept the implication that the original planners escape all responsibility no matter how unworkable their plans prove to be, and that the man on the spot must be responsible for all the possible consequences of the changes which he has to make in order to make the plan workable.

Far be it from me to suggest undue interference with the man on the spot, but if the planning of a colliery is not to be left in the hands of the officials with the direct responsibility of management—and that may be unavoidable in a nationalised industry where the working of a coalfield may have to be planned as a whole—those directing the planning must surely accept their share of responsibility. At the same time the colliery management has an equal responsibility for keeping the planning organisation informed of changes either in the plan or in the working conditions. To define precisely the duties and responsibilities of the various officials is by no means easy. However, I am able to report that the legal position in regard to this and other problems connected with the status and responsibilities of various specialist and other officials is now under review.

VI.—CONCLUSIONS

Summarising the general results of the investigation, it is in my opinion established that :—

- (1) The initial cause of the explosion was an ignition of firedamp on the Third South longwall face caused by the friction of coal cutter picks on pyrites.
- (2) The main issue of firedamp was from an accumulation in large cavities in the waste behind the longwall face and that it was forced out during a roof weight.
- (3) The firedamp accumulated because cavities were left when the roof in the waste failed to cave satisfactorily, and as the face was retreating and had solid sides, there was not the ventilating pressure difference across the waste which, with leakage through the packs into the return, leads to the gradual drainage of firedamp from the waste of an advancing face.
- (4) In the existing conditions adequate caving was unlikely to occur in the early stages of a face opening from a narrow heading and strip packs should have been built until the roof was caving satisfactorily.
- (5) Due consideration was not given to the risk of firedamp accumulation and of roof weight when deciding on the method of work.
- (6) Whilst the explosion was of firedamp up to the point at which it blew through into the intakes at the connections with the First West Materials and Belt Roads, it was thereafter continued by coal dust.
- (7) The coal dust was mainly derived from the conveyor belt and structures, from the vicinity of the transfer points and from the stentons.
- (8) There were defects in the system of dust sampling and in the measures taken to prevent, suppress and treat coal dust.
- (9) Insufficient consideration had been given to the system of ventilation, particularly in regard to the use of the auxiliary fans.
- (10) As a result of weaknesses in the organisation, there was a lack of effective supervision and control.

VII.—SUMMARY OF RECOMMENDATIONS

- (1) Caving should not be practised unless the natural conditions and the method of waste edge support are such that the roof in the waste falls regularly to a sufficient height and in a suitably fragmented state.
- (2) All existing systems of ventilation employing multiple fans should be reviewed and new systems studied to ensure that :—
 - (a) the volume of air circulating is large enough not only to avoid the possibility of re-circulation in any place ventilated by an auxiliary fan, but also to provide for the adequate ventilation of all other working places ;
 - (b) no fan is stopped unless there is alternative means of providing adequate ventilation ; and
 - (c) if it is necessary to regulate a fan it shall be done in such a way as to prevent unauthorised or inadvertent alteration.
- (3) The emission of firedamp from wastes of retreating faces and means of draining firedamp therefrom should be investigated.
- (4) All parties concerned should co-operate to ensure the proper use of firedamp detectors. Also an attempt should be made to develop a combined cap lamp and gas detector that is reliable, gives a good light and is easy to wear.
- (5) Pending the findings of the Working Party the following precautions should be taken :—
 - (a) Wherever coal cutters are in use or are to be used, a survey should be made for the purpose of selecting a cutting horizon, as far as is practicable, clear of any material from which sparks may be struck.
 - (b) The general policy in gassy seams with no clear horizon should be to adopt one of the alternatives to cutting or to adopt measures such as stowage or draining of the wastes to prevent accumulation of firedamp at the waste edge.
 - (c) Steps should be taken to ensure that only sharp picks are used.
 - (d) Water hose with an ample supply of water should be provided within easy reach.
 - (e) Having regard to the dust and sparking dangers, it should be the general policy to avoid dry cutting.
- (6) Everything possible should be done to accelerate progress in the direction of preventing the formation of dust and of suppressing such dust as is unavoidably produced as close to the point of production as is practicable. In particular investigations should be undertaken (a) with a view to extending the applicability of water infusion and to developing its possibilities for working coal, and (b) to hasten the development of coal getting and loading machines operated by slow moving forces.
- (7) A Committee representing the various interests should be appointed to investigate the use of roadway conveyors with a view to determining the limits within which they may be safely and advantageously employed.

- (8) Research should be expedited on the use and development of improved types of dust barriers and water barriers. In the meantime shelf type dust barriers should be installed on conveyor roads.
- (9) Tests should be made to determine the rates of dust deposition in roadways, and experiments should be carried out for the purpose of evolving an improved sampling technique.
- (10) Colliery managements should consult the scientific staff about the organisation of their sampling and stone dusting arrangements ; colliery dust samplers and men in charge of stone dusting should be given a course of training under the supervision of the scientific staff, and should work as a team and to a plan under responsible supervision. From time to time the management should call upon the scientific service to make check surveys and to advise on precautions desirable at special points.
- (11) The assessment of dust samples should be speeded up by the more widespread introduction of optical methods.
- (12) The requirements regarding the medical examination of rescue workers should be reviewed.

Those recommendations on which prompt action is possible have been discussed with the National Coal Board, and I am glad to report that appropriate action has been initiated.

CONCLUDING REMARKS

I wish to express my sincere appreciation for the help and co-operation of the representatives of all parties to the Inquiry and of Mr. H. Offord, Clerk of Court.

I am particularly indebted to Mr. T. A. Jones, H.M. Divisional Inspector of Mines, and his staff ; to Mr. A. H. A. Wynn, Director of the Safety in Mines Research Establishment, and his staff ; and to Mr. W. H. N. Carter, H.M. Senior Inspector of Mines for Special Duties, for his help in the preparation of this Report. I thank also Mr. W. D. Dobson, Chief Surveyor of No. 3 Area, Durham Division of the National Coal Board, and the surveyors and draughtsmen for the excellent plans prepared by them.

I have the honour to be, Sir,

Your obedient Servant,

H. C. W. ROBERTS.

APPENDIX I

LIST OF VICTIMS

<i>Name</i>	<i>Age</i>	<i>Occupation</i>
Anson, John ...	64	Shifter
Armstrong, William ...	55	Datal
Bedding, Mark Smart ...	38	Filler
Blevins, Matthew ...	27	Filler
Brenkley, George ...	20	Filler
Brenkley, Thomas ...	32	Filler
Brennan, Louis ...	49	Stoneman
Brown, George Miller ...	50	Datal
Burn, Bertram ...	25	Filler
Cain, Emmerson... ..	63	Stoneman
Cairns, Frederick ...	23	Filler
Calvert, George ...	50	Stoneman
Calvin, James ...	51	Conveyor Maintenance
Carr, Frederick ...	50	Electrician
Carr, George William ...	45	Timber Drawer
Carr, James ...	38	Timber Drawer
Challoner, John Edwin ...	53	Deputy
Champley, Richard ...	43	Cutter
Chapman, Albert Kerr ...	44	Stoneman
Charlton, Joseph ...	42	Master Shifter
Clough, John ...	57	Shifter
Dryden, William Arthur ...	27	Filler
Ellison, John ...	19	Datal
Fishburn, Charles ...	54	Shifter
Fishburn, Henry ...	23	Filler
Garside, Thomas ...	20	Datal
Godsman, Joseph ...	41	Cutter
Goulburn, George ...	57	Mason's labourer
Gowland, Albert ...	51	Deputy
Goyns, Ernest ...	60	Stoneman
Goyns, Herbert ...	56	Stoneman
Harker, John ...	53	Shifter
Henderson, John William ...	56	Shifter
Heppell, Thomas ...	31	Filler
Hunt, Daniel ...	54	Datal
Hunt, Stephen ...	24	Filler
Hunt, William ...	43	Datal
Hutton, Arthur Chambers ...	42	Filler
Jepson, Frederick Ernest ...	68	Shifter
Jones, Lawrence ...	36	Filler
Jones, Thomas Edward ...	35	Deputy
Jopling, Herbert Jeffrey... ..	57	Shifter
Kelly, John ...	57	Datal
Kelly, William ...	28	Filler
Lamb, John Edward Armstrong ...	43	Datal
Link, Jesse Stephenson ...	44	Datal
Lippeatt, Joseph Fairless ...	37	Filler
Lynch, Peter ...	20	Filler
McRoy, Denis ...	23	Filler
McRoy, William James ...	31	Filler
Milburn, Robert William ...	26	Filler
Nelson, Harold ...	49	Stoneman
Newcombe, Albert ...	67	Stoneman
Nicholson, Norman ...	29	Filler
Noble, Robert ...	45	Shifter

<i>Name</i>	<i>Age</i>	<i>Occupation</i>
Parkin, William ...	24	Filler
Parks, William Edward Forbes	62	Shifter
Pase, Robert	63	Shifter
Peaceful, Stanley	37	Stoneman
Penman, Alexander	42	Cutter
Porter, James	32	Filler
Porter, John Thomas	23	Filler
Rice, Thomas Valentine	53	Shifter
Robinson, John ...	50	Stoneman
Robson, John George	25	Filler
Scott, George	53	Datal
Seymour, Albert	64	Datal
Sillito, Frederick...	52	Shifter
Stubbs, George Henry	60	Shifter
Surtees, Hugh Bell	36	Datal
Surtees, Matthew White	61	Shifter
Thompson, Lawrence	54	Datal
Thompson, Thomas	28	Underground Bricklayer
Trisnan, Thomas	43	Stoneman
Turnbull, Robert	64	Master Wasteman
Wilkie, George ...	63	Shifter
Wilkinson, Reginald	40	Stoneman
Willins, Robert ...	45	Fore Overman
Williams, Matthew	18	Datal
(Fatally Injured—died same day)		
Wilson, John ...	62	Hauling Engineman
Wilson, Stephen ...	60	Shifter
Wallace, John Young	26	Back Overman
(Overcome by noxious gas same day)		
Burdess, Henry ...	43	Deputy
(Overcome by noxious gas 1st June, 1951)		
		(Rescue Worker)

APPENDIX II

LIST OF WITNESSES

<i>Name</i>	<i>Occupation</i>
1. Dobson, William Donald	Area Chief Surveyor
2. Ruell, David Arthur	Area Chief Scientist
3. Kears, Leslie	Datal Worker
4. Leadbitter, Francis	Wagonwayman
5. Cook, Wilfred Bowman	Fore-Overman
6. Bellis, Tom Whomsley	Deputy
7. Wright, Arthur Edward Robson...	Stone Work Instructor
8. Johnson, James	Arcwall Man
9. Gourlay, Alexander Cormack	Power House Attendant
10. Fry, Francis Wilfred	Area General Manager
11. Twist, Henry	Superintendent, Central Rescue Station
12. Donkin, Thomas	Mining Student
13. Davison, William	Deputy Overman
14. Calder, James William	H.M. Senior District Inspector of Mines
15. Sharp, William Clarke	H.M. Medical Inspector of Mines
16. Wharton, Richard	Duckbill Operator
17. Johnson, Stephen Dominic	Conveyor Puller
18. Coils, Ernest	Conveyor Puller
19. Jones, Thomas	Hewer
20. Ayre, Joseph	Duckbill Operator
21. Shipley, Ernest William	Hewer
22. Brown, Sidney Lawrence	Duckbill Operator
23. Whitfield, John Patrick	Duckbill Operator
24. Anderson, Benjamin Cummings...	Duckbill Operator
25. Chapman, George William	Stoneman
26. Harle, John	Stoneman
27. Mortimer, George Wardle	Pipe Fitter
28. Burnhope, John	Stonedust Man
29. Graham, Joseph Collings...	Dust Sampler
30. Crouch, Robert Edward	Fitter
31. Tate, Stanley	Mechanisation Overman
32. Kell, Thomas William	Underground Charge Electrician
33. Lawson, Richard	Electrician
34. Blackwell, Frank	Electrician
35. Carter, Joseph Albert	Electrician
36. Adamson, James George Bowman	Electrician in Charge
37. Wardle, Burton	Police Sergeant
38. Smith, Joseph Cope	Head Lampman
39. Gilmore, Owen	Deputy
40. Scurr, John Joseph	Deputy
41. Hully, Moses	Stoneman
42. Bartholomew, Joseph Arthur	Deputy
43. Keers, Thomas	Deputy
44. Huggins, William	Deputy
45. Rutherford, George Parker	Bargainman
46. Foster, William	Deputy
47. Wilson, Thomas	Deputy
48. Liddle, Joseph	Deputy
49. Leighton, Edward	Chief Practical Instructor
50. Whitfield, David Dixon	Back Overman
51. Barker, Robert	Back Overman
52. Cramond, John	Back Overman
53. Cornish, Robert William	Overman
54. Emery, Hugh Edmund	Undermanager
55. Edwards, David Elwyn	H.M. District Inspector of Mines

<i>Name</i>		<i>Occupation</i>
56.	Hopkins, Thomas	Manager
57.	Morgan, Harold Eustace ...	Assistant Mining Agent
58.	Sneddon, Thomas Nelson ...	Mining Agent
59.	Gascoigne, Errington ...	Area Safety Engineer
60.	Dobson, Robert	H.M. Senior Electrical Inspector of Mines
61.	Davie, Duncan	H.M. District Inspector of Mines
62.	Johnston, Albert	H.M. Electrical Inspector of Mines
63.	Burkle, Basil James	H.M. Electrical Inspector of Mines
64.	Lister, Harold Charles ...	Chief Testing Officer
65.	Robinson, Henry	Principal Scientific Officer
66.	Adamson, James Burt	H.M. Medical Inspector of Mines
67.	Wilson, Harold Frederick ...	H.M. Senior District Inspector of Mines
68.	Boam, William Arthur	H.M. Inspector of Mines
69.	Badger, William Jesse	H.M. District Inspector of Mines
70.	Tideswell, Frederick Vincent ...	Senior Principal Scientific Officer
71.	Carter, William Henry Newton ...	H.M. Senior Inspector for Special Duties
72.	Collins, James Whitelaw ...	H.M. District Inspector of Mines
73.	Jones, John Henry	Scientific Adviser
74.	Collins, Henry Edward	Divisional Production Director
75.	Poole, Granville	Professor of Mining

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